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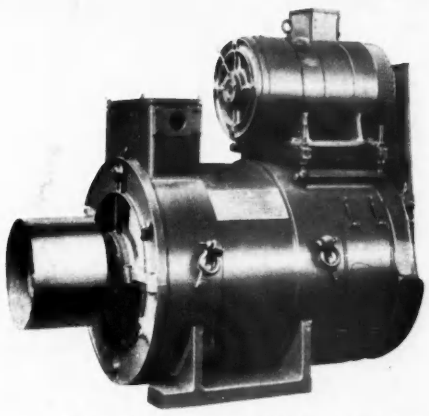

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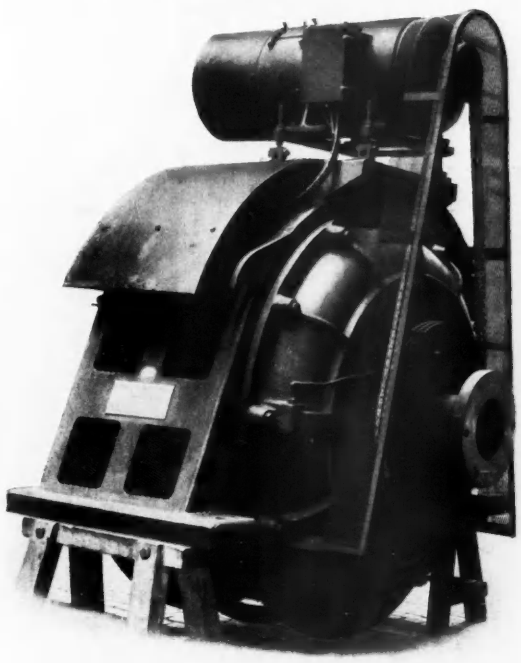

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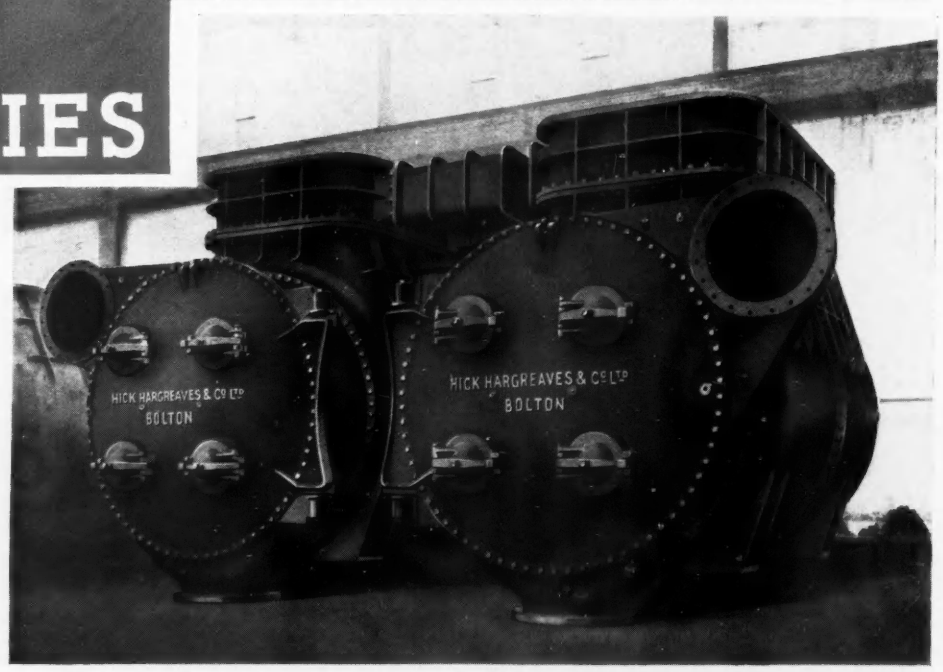


HICK HARGREAVES

A.D.

A Seven-Day Journal

Railway Electrification.

IN a review of the London and North-Eastern Railway Company's business, issued on Thursday, February 28th, together with the annual report, it is announced that the electrification of the company's suburban lines could not be other than a losing proposition, and attention is to be devoted to the improvement of the existing steam service. Several schemes for electrification have been prepared, but the initial and principal difficulty is that the existing lines between Liverpool-street and Stratford are carrying the heaviest service, steam or electric, to be found anywhere in the world. If the lines were electrified the expenditure involved would amount to £7,000,000 and no adequate return could be expected on the outlay. The possibility of a tube scheme has also been considered, but here again the return on the heavy expenditure would be negligible. The question of electrification now rests with the Standing Joint Committee representing the London Transport Board, to whom all details of the proposal have been submitted. Reference to further suburban electrification and to main electrification on the London, Midland and Scottish Railway was made by Sir Josiah Stamp whilst presiding at the company's annual meeting on Friday, March 1st. Although the company's inquiries are not complete, it was stated that there did not appear to be any likelihood of further large-scale outlay in the immediate future. Tests on oil-electric locomotives have indicated, however, that development has sufficiently advanced to justify the company acquiring more units of that type, and an order for twenty 350 h.p. oil-electric 0–6–0 shunting locomotives has been divided between two prominent British engineering firms.

The British Corporation Register.

SPEAKING in Glasgow on February 27th at the annual meeting of the British Corporation Register of Shipping and Aircraft, Mr. Maurice Denny commented upon the steps now being taken to improve the economy of working of ships. Even in the case of the most ordinary kinds of ship, he said, it was now almost a matter of course that a model should be sent to a testing tank before work was begun. In addition marine engineers were busy producing economical engines, boilers and auxiliaries. Shipowners were displaying no lack of courage in giving a fair trial to novelties, particularly those which were intended to supplant or improve upon that standby of the tramp owner—the triple-expansion reciprocating steam engine. Almost every new ship exhibited something new and different in her propelling machinery, so much so that the hope might almost be expressed that engineers would soon settle down to the development of a lesser number of well-marked types which would be the best for their respective services. Speaking of aviation he recalled that at the instance of the Air Ministry the Advisory Committee of Lloyd's Register had been amalgamated with the British Corporation Aviation Committee to form the body known as the Joint Aviation Advisory Committee. The Gorell Committee on the future control of civil aviation had recently recommended that a statutory autonomous body should be formed on the lines of the Joint Committee. There was, Mr. Denny proceeded, an apparent desire to retain the co-operation of the registries without, however, permitting them to retain any control over policy, operations or finance. In other words the societies were to continue to give their reputation and experience in order to provide civil control for civil aviation without having an opportunity either of directing expansion in the future or of recouping themselves for the rather heavy losses inseparable from such pioneer efforts.

The Forth Road Bridge.

ON this page from time to time we have made reference to the scheme for building a road bridge across the Firth of Forth at Queensferry, not far from the famous railway bridge. The matter was taken a stage further forward on Thursday, February 28th, when the Edinburgh Town Council agreed to recommendations upon the financial aspect which were made by Lord Provost Sir William J. Thomson. The cost of the bridge is estimated at £3,650,000, and it is suggested that the Ministry of Transport shall contribute 75 per cent., while the remaining 25 per cent. shall be borrowed on the security of the rates and revenues of Edinburgh. Eventually the sum to the extent of £547,500 would be met by tolls and to the extent of £365,000 by contributions from the city and from the counties of Midlothian, West Lothian, and Fife, and the Town Councils of Dunfermline, Inverkeithing, and South Queensferry. The Lord Provost suggested that the city should bear one half of the local authorities' share up to a sum not exceeding £182,500. The plan on which the estimated cost is based is one for a suspension bridge with a span of 3000ft. and a minimum clearance for shipping of 150ft. above high water. It would be situated about half a mile westward of the railway bridge and have one main tower on the Mackintosh Rock and the other clear of the entrance to Port Edgar. This southern tower would be founded on good sand or boulder clay at a depth not greater than 110ft. below high water. The roadway carried by the bridge would be 30ft. in width and some improvement would be necessary to the existing roads giving access to the site. The engineers to the scheme, who have submitted a report and plans, are Messrs. Mott, Hay and Anderson.

Aero Engine Developments.

SPEAKING at the twenty-first ordinary general meeting of D. Napier and Son Ltd. on March 1st the chairman, Sir Harold Snagge, told the shareholders something of the progress which the company had made in the development of its new aero engines. He announced that they were shortly to receive a substantial order from the Air Ministry for "Dagger" engines with which to equip a squadron of Royal Air Force machines. The "Dagger" engine has twenty-four cylinders arranged in four banks of six each about two crank shafts and is air cooled. It is supercharged and at maximum "boost" can develop up to 760 b.h.p. The frontal area is very small, amounting to about one square foot per 110 h.p. We illustrated this engine in our issue of January 18th this year. In the same issue we also illustrated the Napier-Junkers "Culverin" compression-ignition aero engine. Concerning this engine Sir Harold told the meeting that satisfactory progress was being made and that an order for "Culverin" engines was now in course of execution for the Government. The smaller version, known as the "Cutlass," exhibited a markedly better power-weight ratio and it was anticipated that a fair market would be found for it as well as for the "Culverin" in the course of time. Speaking generally he said that while to-day they spoke in terms of 800 and 1000 h.p. engines as compared with 400 or 500 h.p. only a few years ago, there were indications that the limit of horse-power in single-engine units had not yet been reached. Progress in the flying industry was very rapid and no one could say when some new discovery or development would come along and necessitate a completely new outlook on the part of the engine manufacturers. Nevertheless, he looked forward to the not distant future when with the engines now under development the company would regain the prosperity which it enjoyed when the "Lion" engine held an almost unchallenged position in the world of aeronautics.

The Institution of Civil Engineers.

ON Wednesday of last week, February 27th, the annual dinner of the Institution of Civil Engineers was held at the Savoy Hotel. The guest of honour was H.R.H. the Duke of York, who, in proposing the toast of "The Institution," said that such a very big share had been taken in the welfare of the human race by the civil engineer that he might easily to-day be termed the "engineer of civilisation." In undeveloped lands, where he had introduced railways, canals, or any other form of communication, civilisation had followed closely upon his tracks. The romance of the work of the civil engineer lay in the fact that what to-day might seem a dream or a rather wild prophecy could be converted by his genius into an accomplished fact. In reply, the President, Sir Richard Redmayne, said that the members of the Royal Family were ever ready to give assistance to the objects which the great societies of science and technology had at heart. It might be said that out of the Institution of Civil Engineers had sprung all the other engineering societies as and when the need for specialisation became necessary owing to the advancement in knowledge and discovery. The toast of "The Houses of Parliament" was proposed in amusing and witty vein by Lord Macmillan and Sir John Simon responded. To Sir Brodie Henderson, a past-President of the Institution, fell the task of proposing the toast of "The Guests"—a difficult one, indeed, when so many distinguished persons were present. The Swiss Minister and Lord Tomlin responded.

Railway Air Services.

AT the annual meetings of the Great Western, Southern, and London, Midland and Scottish Railways held last week separate references were made in each case to the undertaking known as Railway Air Services, Ltd., a company established by the joint efforts of the four main line railway companies and Imperial Airways, Ltd. Sir Robert Horne told the Great Western shareholders that within the past few weeks the company had concluded in conjunction with the Southern Railway Company an arrangement giving it an interest in the air service between England and the Channel Islands, a route which was already very popular and which would become still more attractive when the landing facilities at Jersey and Guernsey had been improved. During the year the mileage of the air services operated within the company's territory had increased by more than 50 per cent. as compared with the previous year. Simultaneously the loss on working had been reduced from £6526 to £5150. Speaking to the shareholders of the Southern Railway Mr. R. Holland-Martin said that the receipts from air transport had amounted to £272 and the expenditure upon it to £5042. The company, he explained, was interested in two air routes. One, operated in conjunction with the Great Western Railway, connected Birmingham, Bristol, Portsmouth and Cowes. The machines for this service could not be obtained until well on into July and consequently the service had been in operation for only about two months. The loss on it amounted to about £900. The other service was one between London and the Isle of Wight operated in conjunction with Spartan Air Lines, the agreement providing that the railway company should receive half the profits or pay half the losses. The experiment had cost the company £3200. To the L.M.S. shareholders Sir Josiah Stamp admitted that the company's air services had been maintained at a loss but with a regularity, over six months, of 91 per cent. As air transport developed costs, he said, might go down and at some stage actual profitability should be reached.

Rural Electrification.

SPEAKING at the forty-sixth annual general meeting of the Northampton Electric Light and Power Company, Ltd., the chairman, Mr. F. H. Thornton, explained that, although the company supplied directly or through its associated companies an area of approximately 1000 square miles of a mainly agricultural nature, and offered electricity to nearly 90 per cent. of the population, the results so far as agricultural use was concerned were rather disappointing. Although every endeavour had been made to stimulate the business by a cheap tariff, by assisted wiring, and by the hire-purchase system, and although the company had nearly 600 farmers connected to its lines, it was found that only 5½ per cent. of those consumers used electricity for genuinely agricultural purposes. The remainder employed it for practically nothing but ordinary domestic purposes in the farmhouse. It was to be hoped that when agricultural conditions improved and farmers appreciated the value of time and labour saving machinery more fully, they would find it worth while to use more current for their farming operations. There was no justification in the company's area, at any rate, for the complaint that insufficient attention was being paid to rural electrification requirements.

Defence Against Air Attacks.

ON February 27th the Under-Secretary of State for Air was asked in the House of Commons whether consideration had been given to the advisability of an early investigation of the possibilities of countering air attacks by utilising the recent progress of scientific invention and, if so, whether it was intended to enlist the assistance of scientists outside the Government service. Replying, Sir Philip Sassoon said that some months ago it had been decided to appoint a special committee to investigate the subject as a matter of urgency and to obtain for that committee the services of a number of distinguished outside scientists. That committee was already at work. In addition to the Director of Scientific Research at the Air Ministry, the only official member, the committee consisted of Mr. H. T. Tizard, rector of the Imperial College of Science (chairman); Professor A. V. Hill, Foulerton Research Professor of the Royal Society; and Professor P. M. S. Blackett, Professor of Physics in the University of London. It was the intention to invite other distinguished scientists to contribute to the investigation. The committee's report would, in due course, be laid before the Committee of Imperial Defence. In the important statement by the Prime Minister which was published on March 4th reference was made to the same subject in more general terms. A necessary complement to defensive measures, Mr. MacDonald said, was the protection of the civil population and of essential services from the effects of bombing from the air. The Government intended, he added, to develop such protection simultaneously with the expansion of the armed forces.

L.N.E.R. Record Run.

ON Tuesday March 5th a London and North-Eastern train consisting of the seven-year-old engine "Papyrus," three first-class corridor coaches, a restaurant car, a brake van and a dynamometer car, left King's Cross at 9.8 a.m. on a speed trial to Newcastle and back. The down run was slightly checked as the result of some goods trucks having been derailed near Doncaster. In spite of that delay, however, Newcastle was reached at 1.4½ p.m. nearly four minutes ahead of the intended time and actually 1 h. 10½ min. sooner than the regular "Flying Scotsman" would have arrived on the same trip. The down run of 268 miles was thus accomplished in 3 h. 56½ min. or at an average speed of 68·6 miles an hour. Some hours later the same train left Newcastle on the return trip which was performed in 3 h. 51 min. or at an average speed of 69·6 miles an hour. On the up run near Little Bytham in Lincolnshire the train reached a speed of 108 miles an hour and for 12¼ miles between Corby and Tallington maintained an average speed of 100·6 miles an hour. It may be recalled that on November 30th, 1934, the L.N.E.R. carried out similar experimental runs between London and Leeds. On that occasion the train consisted of a three-cylinder "Pacific" engine built in 1923 and four vehicles. On the down run the average speed was 73·4 miles an hour and on the up run 70·8. At one point the speed touched 100 miles an hour.

The Development of Parsons Industrial Turbo Machinery.

No. IX.

(*Continued from page 218, March 1st.*)

Pass-out Turbine for Rope Works.

A PASS-OUT turbine, as the name implies, is a turbine from which a certain quantity of partially expanded steam can be extracted for heating or other purposes, the remainder of the steam completing its expansion in the turbine and exhausting to the condenser in the usual way. Whenever low-pressure steam is required for heating or process work in a factory which has at the same time a demand for power, the use of a pass-out turbine is particularly advantageous. There is, in practice, no appreciable difference in the quantity of fuel required for generating high-pressure or low-pressure steam, so that by producing steam at high pressure and expanding it to the lower pressure required for heating by passing it through a turbine power can be obtained from the turbine at a negligible cost. Moreover, steam taken from a turbine in this manner is as pure and as free from oil as if it were taken directly from a boiler. This perfect cleanliness makes it suitable for use in heating systems of every kind, and it can, indeed, be even used for direct admixture with materials destined for human consumption, an example of such use having already been mentioned in connection with the description of the turbine supplied to Messrs. Guinness' brewery.

The first pass-out turbine to be constructed at the Heaton Works formed part of a 1000-kW turbo-alternator unit built in 1912 for the Edinburgh Ropery and Sailcloth Company, Ltd., of Leith. It was supplied with steam at a gauge pressure of 180 lb. per square inch at the stop valve, superheated to 580 deg. Fah. Steam in quantities up to a maximum of 5000 lb. per hour was extracted from the turbine after expansion down to an absolute pressure of 35 lb. per square inch. The remainder of the steam completed its expansion in the turbine blading, exhausting into the condenser at a vacuum of 28·2in.

A partial section through the turbine is given in Fig. 82. The blading, as will be seen, was divided into two parts by a diaphragm and labyrinth gland around the circumference of the rotor. The whole of the steam entering the turbine passed through the blading on the upstream side of this diaphragm and then left the cylinder to go to the automatic pass-out chest, a section of which is reproduced in Fig. 84. The steam entered this chest by the branch A. The quantity required for heating purposes left immediately by the branch B, while the excess passed downwards through the valve, leaving by the branch C, to re-enter the turbine on the downstream side of the diaphragm. The function of this pass-out valve was to maintain a constant absolute pressure of 35 lb. per square inch at the outlet branch B and it effected this duty automatically by very simple means.

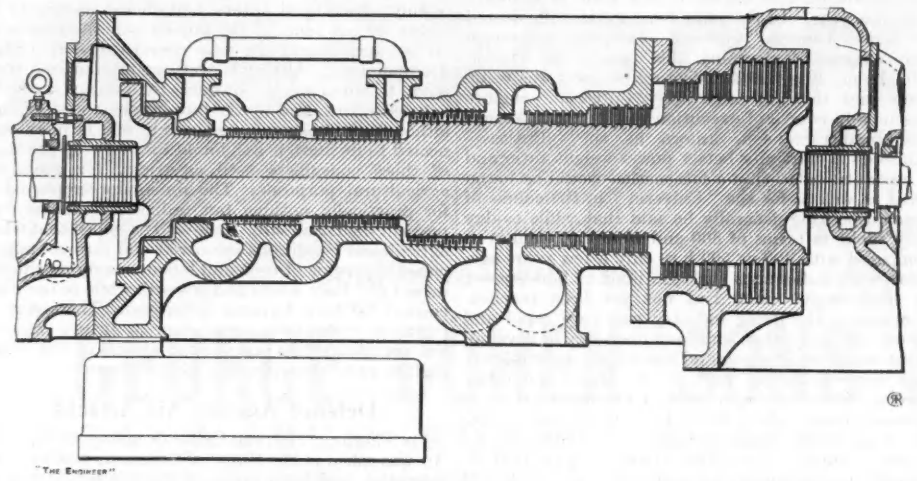


FIG. 82—1000-KW PASS-OUT TURBINE FOR EDINBURGH ROPERY—1912

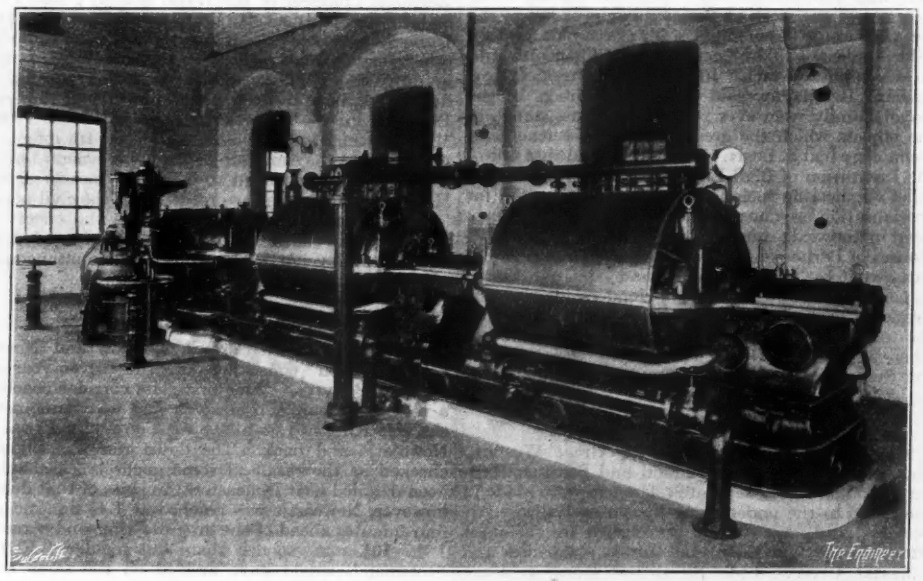


FIG. 83—5000-CUBIC FOOT TURBO-COMPRESSOR FOR PEMBERTON COLLIERY—1911

At the upper end of the spindle of the pass-out valve will be seen a spring-loaded piston tending to close the valve. Steam was admitted continuously beneath the piston by a needle valve, its escape being regulated by the position of a spring-loaded plunger at the side. A piston was attached to the lower end of the plunger, and steam from the valve chest, and therefore at the pressure which had to be kept constant, was admitted beneath the piston by means of a small pipe from the valve chest. If the pass-out pressure rose, it is evident that the relay plunger would be lifted against the action of its spring. The plunger would then restrict the escape of steam from beneath the relay piston on the valve spindle, causing the pressure there to increase and the pass-out valve consequently to be opened wider. More steam would therefore be diverted back to the turbine, so that the pass-out pressure would be restored to the normal. If the pass-out pressure tended to fall owing to a greater demand for heating steam, normal pressure would immediately be restored by the converse of the action described above. The actual pass-out pressure could be varied between reasonable limits by adjustment of the tension of the spring acting on the relay plunger.

It will be observed that the regulation of the pass-out pressure was entirely independent of the action of the main speed governor of the turbine. The pass-out mechanism had nothing to do but to keep the pressure of the heating steam constant, without regard either to the electrical load on the machine or to its speed. The duty of the main governor was to admit the required quantity of steam to keep the speed constant. If more steam were required for heating the smaller quantity returned by the pass-out valve to the low-pressure blading of the turbine would tend to reduce the speed, and the governor would then correct this by admitting the extra amount of steam required. Similarly, if the electrical load increased, the governor would admit more steam in the usual way, the pass-out valve meanwhile confining itself to its sole purpose of keeping the pass-out pressure constant.

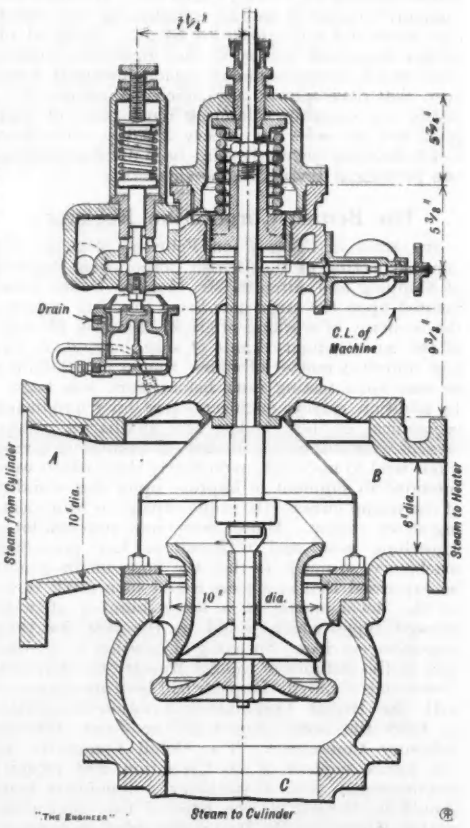


FIG. 84—PASS-OUT VALVE OF EDINBURGH TURBINE

The method of control proved satisfactory, and the turbo-alternator continued in service at the Edinburgh Ropery Works until 1928, when it was purchased by the Burghlee Byproduct Company, Ltd., and installed at Loanhead, Midlothian.

The Introduction of Automatic Pressure Regulation on Turbo Compressors.

The pressure of the air delivered by the earlier turbo-compressors was usually controlled by the speed of the turbine, either automatically or by hand regulation, no attempt being made to "unload" the compressor when the demand for air was reduced. This system, besides being uneconomical, was not conducive to the maintenance of a very constant delivery pressure, and an advance was made upon it in connection with a turbo-compressor constructed for the Pemberton Colliery, near Wigan, in 1911. The machine in question was also marked by a number of improvements in details of design, particularly as regards the provision made for internal cooling. Its normal duty was to deliver 5000 cubic feet of free air per minute at a gauge pressure of 65 lb. per square inch. The turbine was of the mixed pressure type, operating with steam at a gauge pressure of 90 lb. per square inch, or at an absolute pressure of 16 lb. per square inch. The governor and valve gear were of the standard design for the time, as illustrated in Fig. 62 (*ante*). A photograph of the complete machine in position is reproduced in Fig. 83.

Comparing the section through the compressor, given in Fig. 85, with the earlier design illustrated in Fig. 75 (*ante*), it will be noticed that, whereas in the

earlier machine the cooling water had access only to one side of each guide passage, in the Pemberton compressor additional cooling surface was obtained by arranging that a large part of each passage should be completely surrounded by water. Furthermore, to reduce the overhung weight between the centre bearings, a new type of coupling was fitted. The claw piece on the end of the high-pressure shaft was retained, but the toothed sleeve which embraced it was connected to the low-pressure shaft by a distance piece held in position by a single bolt.

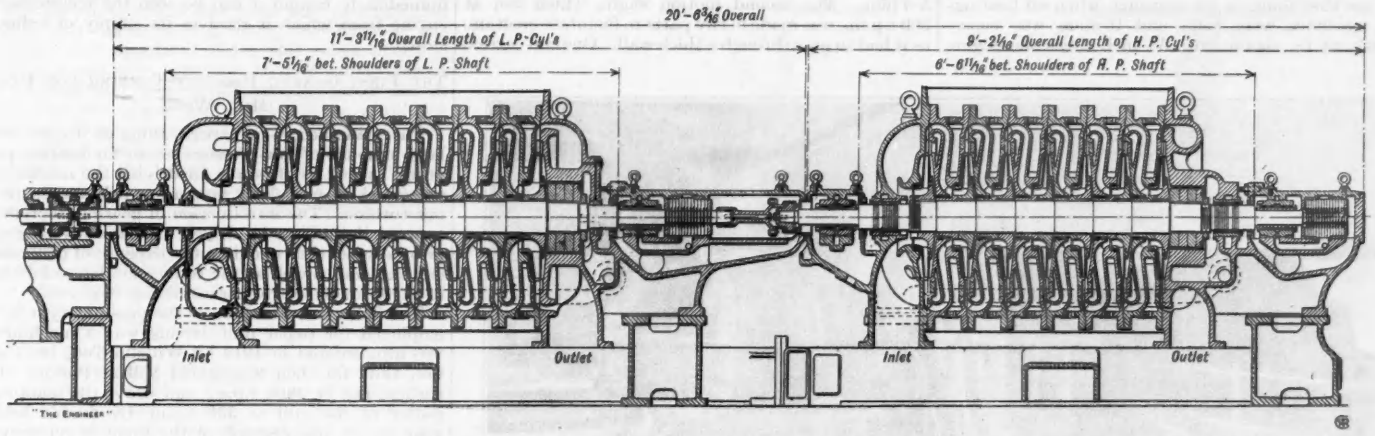

20'-6 3/16" Overall
11'-3 11/16" Overall Length of L. P. Cyl's
7'-5 1/16" bet. Shoulders of L. P. Shaft
8'-2 1/16" Overall Length of H. P. Cyl's
6'-6 11/16" bet. Shoulders of H. P. Shaft
Inlet
Outlet
Inlet
Outlet
"The Engineer"

FIG. 85—LONGITUDINAL SECTION THROUGH CYLINDERS OF TURBO-COMPRESSOR FOR PEMBERTON COLLIERY—1911

The special feature of the plant, however, was the arrangement for securing constant pressure of the delivery air. Referring to Fig. 86, it will be seen that the air discharged from the high-pressure cylinder passed through a double set of non-return valves on its way to the receiver. A small pipe connected to the receiver side of the non-return valves communicated the delivery pressure to the chamber A of the air governor. This governor consisted essentially of a plunger B loaded with a suspended weight. If the delivery pressure rose above a predetermined point the weight was overcome, the plunger lifted, allowing the pressure to be communicated through a port and a second pipe to the upper end of a cylinder C. A piston D in this cylinder was therefore forced down, operating a butterfly valve in the air inlet pipe, and so throttling the supply of air to the compressor.

To avoid trouble from the possible surging of the air pressure when the machine was being started, or after a sudden reduction of its load, a surge relief valve F was fitted to the pipe between the compressor and the non-return valves. The valve F opened inwards to the pipe and tended to be kept in the open position both by its own weight and the action of a light spring. Normally it was held shut by the pressure of the air beneath it, but in the event of surging it opened automatically, admitting external air and destroying the conditions of instability which had allowed surging to arise.

GEARED EXHAUST TURBINES FOR JUTE MILLS.

Twenty-five or thirty years ago the typical jute mill in India was driven by a slow-speed reciprocating engine, power being distributed to the various line shafts by means of cotton ropes. When extensions to a mill became necessary, a second engine of the same kind was installed, working independently of the first, and driving its own sections of the machinery. Both engines took their steam from the same boiler-house, and as the steam was raised in Lancashire boilers of reasonably high pressure equipped with economisers and superheaters, the costs of power were very low. In fact, in the opinion of most mill managers, the system could not be improved upon, either as regards economy or reliability.

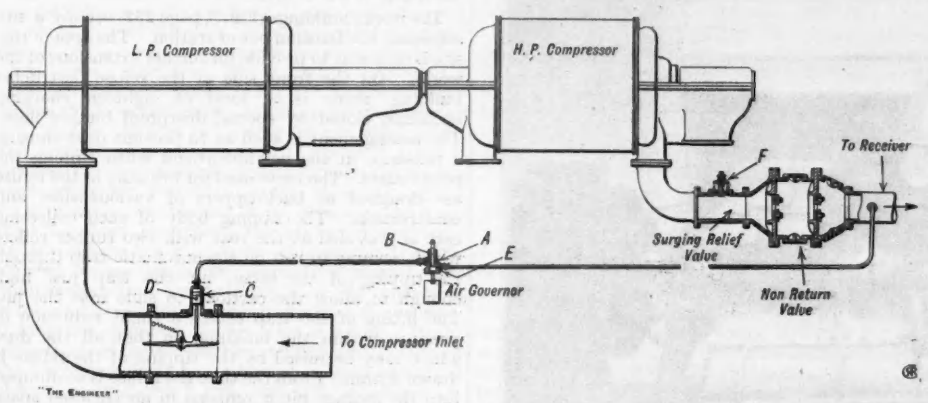


FIG. 86—DIAGRAMMATIC ARRANGEMENT OF CONSTANT DELIVERY PRESSURE GOVERNOR

However, about the year 1911 Messrs. Bird and Co., of Calcutta, who were managing agents for a number of large jute mills, decided to examine the possibility of still further reducing the working costs of two-engined mills by substituting an exhaust steam turbine for one of the reciprocating engines, the turbine, of course, to be driven by the exhaust steam from the other engine.

The first idea was naturally to employ a turbo-generator, and to drive a portion of the mill electrically. Calculations, however, soon made it evident that if the turbine had to generate electricity and drive the shafting by motors, the losses involved in the double conversion of energy would leave little or no room for economy by the adoption of the system. It appeared, on the other hand, that if the turbine was fitted with mechanical speed-reducing gear, so that the principle of rope driving could be retained, a very substantial saving might be effected. The question was taken up with Messrs. Parsons, who undertook to supply machinery suitable for the purpose, and to guarantee the results. Consequently, in 1912 an order was placed with them for a geared turbine capable of developing 700 h.p. from the exhaust steam of one of the reciprocating engines in the Union Jute Mills, of Calcutta, and so enabling the other reciprocating engine to be shut down. The engine which was to be retained was of the horizontal cross-compound type, manufactured by Hick, Hargreaves and Co., Ltd., of Bolton, with cylinders 27in. and 54in. in diameter, and a stroke of 5ft. It worked with steam at a pressure of 150 lb. per square inch, superheated to 475 deg. Fah. at the stop valve, and, as originally arranged, exhausted into a jet condenser. This condenser was done away with,

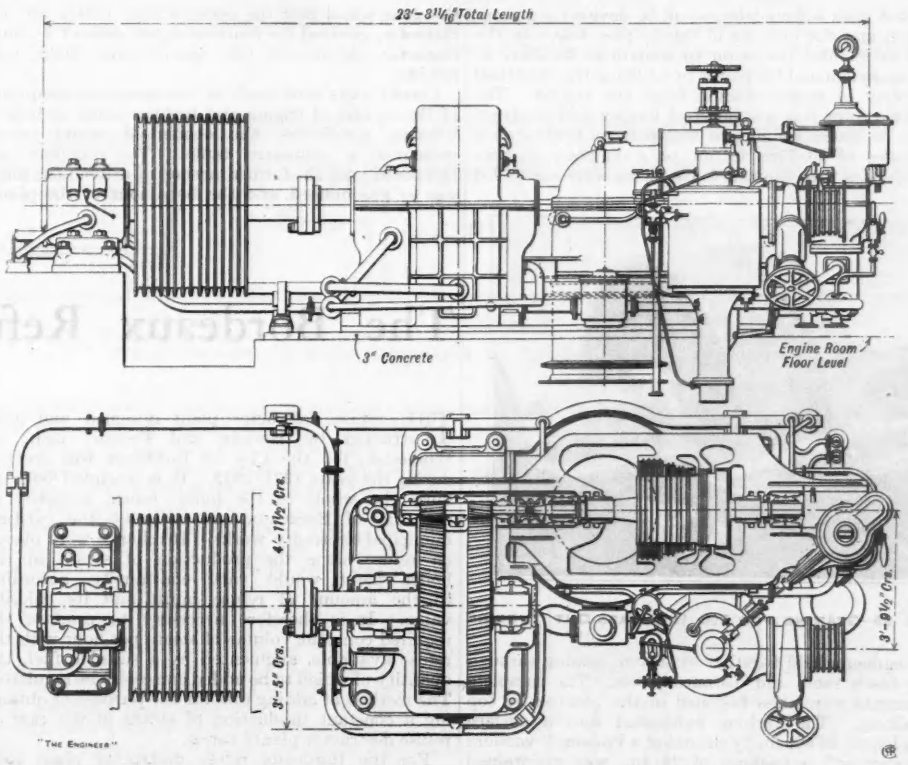


FIG. 87—700 B.H.P. EXHAUST TURBINE AND GEARING FOR JUTE MILL—1912

and the exhaust from the engine made to pass through an oil separator, and then to the new turbine, whence it was finally discharged into a surface condenser.

It would have been in accordance with the standard practice of jute mills to have arranged that each prime mover should drive its own section of the mill independently of the other, but since, under these conditions, the variation of load as between the two sections would have resulted in there being sometimes too much and at other times too little exhaust steam available for the turbine, it was decided to run the whole of the mill as one unit, driven by the engine and the turbine working in parallel. Such a combination of a reciprocating engine working in parallel with a pure exhaust turbine had never previously been attempted in mill practice, but the enterprise of all the parties concerned was fully justified by the results, as the plant gave the utmost satisfaction from the start. The arrangement, moreover, avoided the necessity of employing a mixed-pressure turbine, to carry the load in case of a shortage of exhaust steam, and made both for economy and simplicity. Furthermore, owing to the mechanical connection between the two prime movers, it would have been quite possible to do away with any speed governor on the turbine, but it was considered wiser to adhere to standard practice in this respect, so that the usual speed governor and runaway governor were both fitted. Normally, of course, the turbine worked with nothing but the exhaust steam from the engine, but it was possible to operate it independently of such steam in case of emergency, by a supply of live steam admitted through a pressure reducing valve.

The arrangement of the turbine and gearing is shown in Fig. 87. The turbine was designed to develop normally 700 h.p. at a speed of 3000 r.p.m., but this power could be increased by 20 per cent. by opening a hand-operated by-pass valve. The object of this provision was to facilitate the starting of the mill the first thing in the morning, when all bearings and machines were cold, and friction was consequently at its maximum. At such times the engine worked with a very late cut-off to develop a greater power, and the opening of the by-pass valve on the turbine enabled the latter to contribute its share to the extra demand for power by utilising the abnormal quantity of steam coming from the engine. The turbine rotor was a solid steel forging with thirteen rows of blades ranging in length from 1·63in. on a diameter of 23·75in. to 5in. on a diameter of 22in. The blades with their distance pieces were assembled in segments held together by a wire passing through the blade roots and distance pieces. The complete segments were then fastened in the grooves by top caulking. The turbine exhausted into a surface condenser, in which, by the aid of a Parsons "vacuum augmentor," a vacuum of 26·4in. was maintained at full load with a barometer reading of 30in. and a cooling water temperature as high as 95 deg. Fah.

The gear was of the double helical type with a reduction ratio of approximately ten to one. The pinion shaft, of nickel steel, was carried in three bearings, one bearing between the two halves of the gear, and was driven from the turbine by a flexible coupling. The pinion had thirty-two teeth cut at a spiral angle of about 45 deg. on a pitch diameter of 5·716in. The second motion shaft, which ran at 300 r.p.m., was made in two parts to facilitate erection, as it had to pass through a thick wall. One end carried the gear wheel and the other a rope pulley 5ft. in diameter, grooved for fourteen ropes, each of 1·75in. diameter, the normal rope speed being 4700ft. per minute.

Careful tests were made of the steam consumption of the combined engine and turbine under ordinary working conditions, the condensed steam being measured in calibrated tanks. The economy, as compared with the former method of driving the mill, was so pronounced, and the behaviour of the plant was so satisfactory, that two other jute mills, the Dalhousie and the Lawrence mills, were almost immediately converted to the new method of driving. In these mills larger exhaust turbines were employed, each having a rated capacity of 1250 b.h.p. Fig. 88 shows the geared turbine in the Lawrence mill, and immediately behind it can be seen the reciprocating engine from which it receives its supply of exhaust steam.

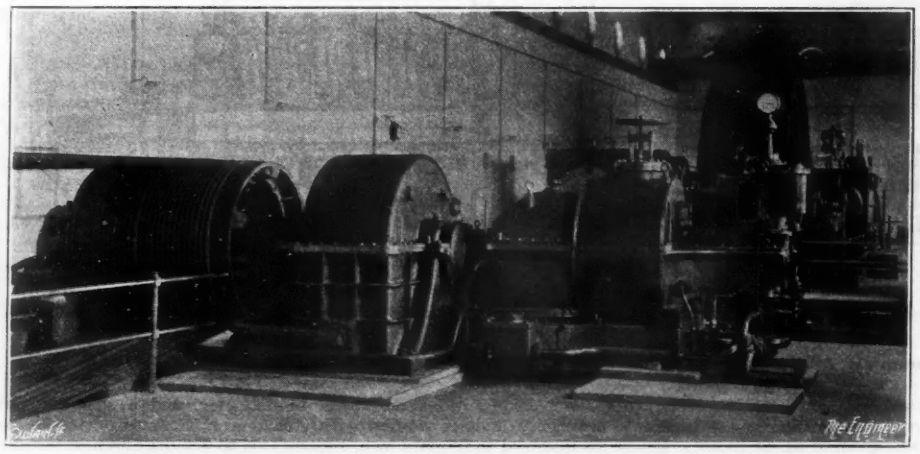


FIG. 88—1250 B.H.P. EXHAUST TURBINE IN LAWRENCE JUTE MILL—1913

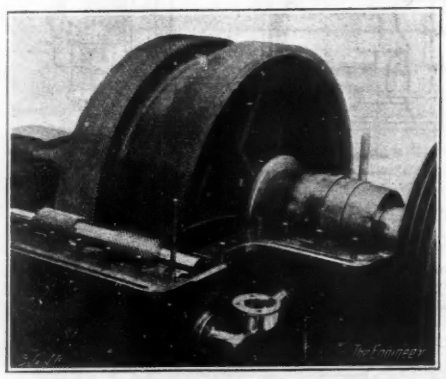


FIG. 89—GEARING FOR 800 H.P. PASS-OUT TURBINE

THE FIRST GEARED PASS-OUT TURBINE FOR PAPER MILL WORK.

The manufacture of paper, calling as it does for a large amount of low-pressure steam for heating purposes, as well as of power for driving the machinery, presented a particularly favourable field for the pass-out turbine. The introduction of gearing, moreover, enabled the mill to be driven mechanically by ropes or otherwise, thus avoiding the expense of generators and motors, as well as the conversion losses inherent in any form of electrical transmission of power.

The first geared turbine of the pass-out type to be employed for paper mill driving was a machine of 800 h.p. ordered in 1912 by William Tod, jun., and Co., Ltd., for their Springfield Mill at Polton. The turbine ran at 3600 r.p.m. and drove the main rope pulley of the mill at 330 r.p.m. by double helical gearing. A photorgraph of the plant is reproduced in Fig. 90, and the appearance of the gearing with the cover removed is shown to a larger scale in Fig. 89. The turbine worked with steam at a gauge pressure of 150 lb., superheated to 516 deg. Fah. at the stop valve, and passed out partially expanded steam at 35 lb. gauge pressure for heating. The pressure of the heating steam was maintained constant by an automatic pass-out valve of the type illustrated in Fig. 84 above, contained in a separate steam chest alongside the cylinder of the turbine.

The operation of the mill depended entirely upon the turbine, as there was no stand-by plant installed. The confidence in the reliability of the machine was, however, fully justified, for it had a record of driving the mill for 4½ years, with the loss of only one half-hour of working time during that period which could be attributed to the machine itself.

(To be continued.)

The Bordeaux Refuse Destructor Plant.

THE refuse destructor plant designed and constructed by Heenan and Froude, Ltd., of Worcester, for the City of Bordeaux was erected during the years 1931–1933. It is intended both to burn the whole of the house refuse collected in the City of Bordeaux and to assist the existing municipal electricity works. If reliance were placed on refuse alone the production of steam in the boiler plant would vary continually, according to the amount of refuse burnt and its calorific value. It is therefore necessary to produce the required constant volume of steam per hour with the refuse available, augmented by a suitable fuel, the quantity of which to be added can easily be regulated. The method of adding coal for the purpose of obtaining a constant production of steam in the case of refuse destructor plants varies.

For the Bordeaux refuse destructor plant each steam boiler has alternative means of firing, consisting of the special refuse destructor furnace and of a coal-fired mechanical stoker. The use of a modern stoker for burning the added fuel presents the advantage that the fuel can reach it for firing in the form in which it is available. There is no need for any previous special treatment, such as is required when firing with powdered coal. The mechanical stoker is built in under the steam boiler, in the ordinary way, while the arrangement of the necessary furnace arch and also that of the clinkering operation, have been kept in the same form as in the case of a normal grate. The supply of gases coming out of the refuse destructor furnaces is made possible by raising the combustion chamber between the top of the stoker grate and the first boiler tubes somewhat higher than is generally done. This arrangement provides sufficient space at the front of the boiler for installing a special gas flue, connecting the refuse destructor furnace with the boiler plant. This gas flue is carried high and arranged above the furnace arch of the moving grate. The front of the boiler is fitted with two large gas admission openings, through which the refuse gases can flow into the combustion chamber of the boiler. In the combustion chamber, the gases become mixed with the coal gas coming from the moving grate, and from that point the gas mixture goes through the whole of the boiler.

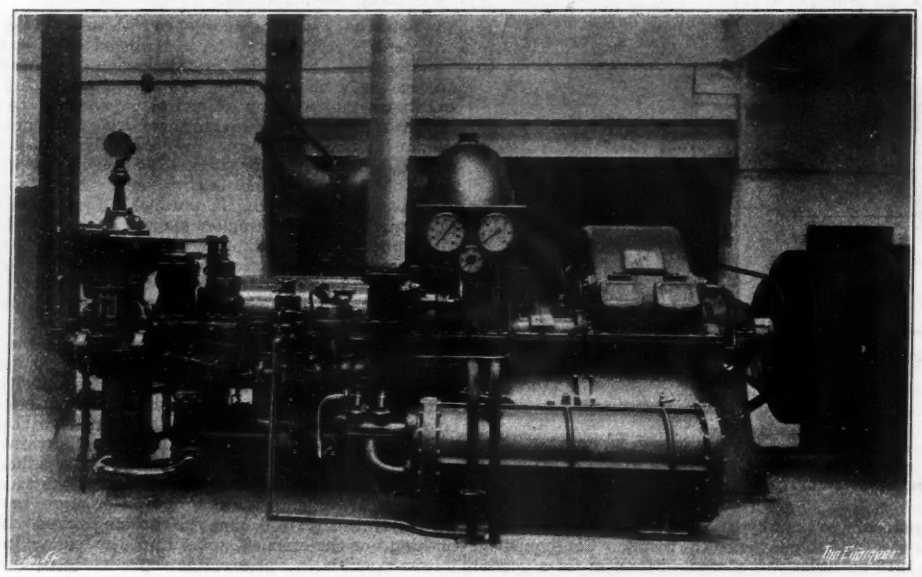


FIG. 90—800 H.P. GEARED PASS-OUT TURBINE FOR PAPER MILL—1912

The works buildings (Fig. 5, page 252) occupy a site adjoining the Bacalan power station. The area of this site is sufficient to provide for further extensions of the works. On the front side of the refuse destructor building there is a total of eighteen charging openings, closed by special dustproof bunker flaps. The arrangement is such as to prevent dust causing a nuisance in the neighbourhood when tipping the refuse carts. The carts used for bringing in the refuse are designed as back-tippers of various sizes and construction. The tipping body of each collecting cart is provided at the rear with two rubber rollers which, coming to rest on the automatic trap through the tipping of the body, lift the trap just high enough to allow the cartload to slide into the pit. The lifting of the trap causes a slight reduction of pressure within the building, so that all the dust which may be raised by the tipping of the refuse is drawn within. From the time the refuse is so dumped into the storage pit it remains in an enclosed space until its complete destruction, and, in addition, no contact with the *personnel* is tolerated. Inside the building a deep refuse bunker with a capacity of roughly 800 cubic metres is arranged parallel to the frontage. Of this, about 750 cubic metres are reserved for refuse, and 50 cubic metres for the coal.

The refuse is picked up from the storage pit by

powerful grabs suspended from travelling cranes, and is delivered direct without any preparation of any kind (sorting, screening, &c.) to the feed hoppers situated above the furnaces. The storage pit is of reinforced concrete and is divided into two compartments, so that each in turn may be completely emptied for the purpose of cleaning. The operation of the travelling cranes and grabs may be controlled either from cabins jutting out of the front of the building and separated from the refuse-handling room by sealed glass windows, or from cabins carried by the travelling cranes, but entirely closed, also in sheet iron and glass, and supplied by a small fan with air slightly compressed and filtered, so that the cranemen may be protected from dust. It may be noted that the upper edge of the feed hoppers of the furnaces is provided with a suction arrangement connected to a dust extractor described later. Thus, the dust raised by the opening of the grab over the hoppers is removed by suction. The travelling grab cranes sweep both the whole of the deep refuse bunker and an elevated platform, through which are fed the refuse feed hoppers and the coal hoppers. The plant is designed at present for three groups of five refuse feed hoppers, and for three coal hoppers. The coal hoppers stand on the centre line of the steam boilers, and the individual refuse feed hoppers are arranged above each cell. For the present, only four cells and feed hoppers are provided for each destructor unit ; when an addition is made, a fifth cell and feed hopper will be added. Each individual feed hopper has a capacity of roughly 6 cubic metres, and each coal hopper a capacity of 42 cubic metres.

The refuse delivered to the feed hoppers of the

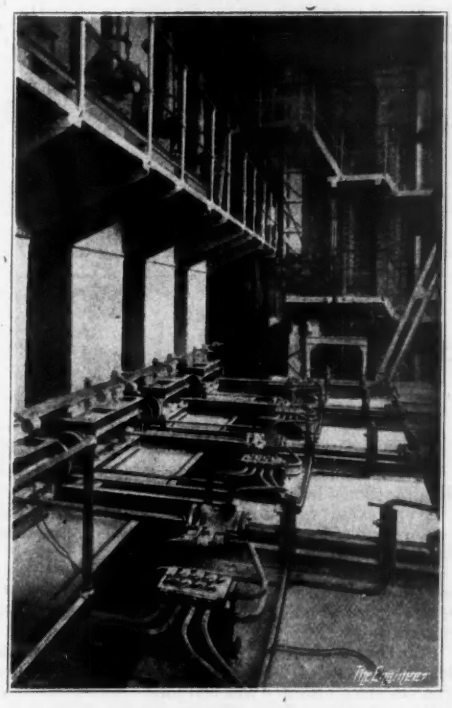


FIG. 1—FEED BUNKERS ABOVE FURNACES

furnaces passes over a conveyor into the bunkers of 10 cubic metres capacity, arranged over each furnace cell—Fig. 1. This arrangement makes it possible to hold above the furnaces a sufficient quantity of refuse to feed them for several hours, thus considerably alleviating the work of handling the refuse, and providing for a reserve.

The design of the Heenan and Froude furnaces is diagrammatically shown in Fig. 2. The furnace grate is divided into a number of separate grate sections, each of which is intermittently fed with a small charge of refuse. As a result the refuse is burnt in thin layers spread over a large area. The combustion chamber is common to all the sections. In Fig. 2, A, the feed hopper for the single section shown, is awaiting replenishment with refuse. Refuse is burning on the main grate, and beneath it a secondary or "clinker" grate is covered by incandescent clinker through which the combustion air travels to reach the main grate. As soon as the combustion of the refuse on the main grate has been completed, the grate "disappears" by travelling—see Fig. 2, B—discharging the still glowing clinker on to the secondary grate below. Simultaneously, a scraper carried on the underside of the main grate removes the clinker from the furnace. During this operation the air blast is cut off. Meanwhile the feed hopper has been refilled, and so soon as the travelling grate has returned a fresh measured charge is introduced into the cell, as shown in Fig. 2, C. The last diagram in Fig. 2 shows a longitudinal section of a furnace, each section being at a different point in the cycle. Each grate section has a refuse grate of 2·42 square metres and a clinkering grate of 3·3 square metres. The whole furnace block is surrounded by a sheet steel casing 6 mm. thick. The lining of each furnace block has a total thickness of 370 mm., the inside having a lining of fire-clay 220 mm. thick, added to a layer of insulation 105 mm. thick, and a further layer of slag wool 45 mm. thick. The whole furnace structure is carried on steelwork, running down to the basement floor. The hoppers

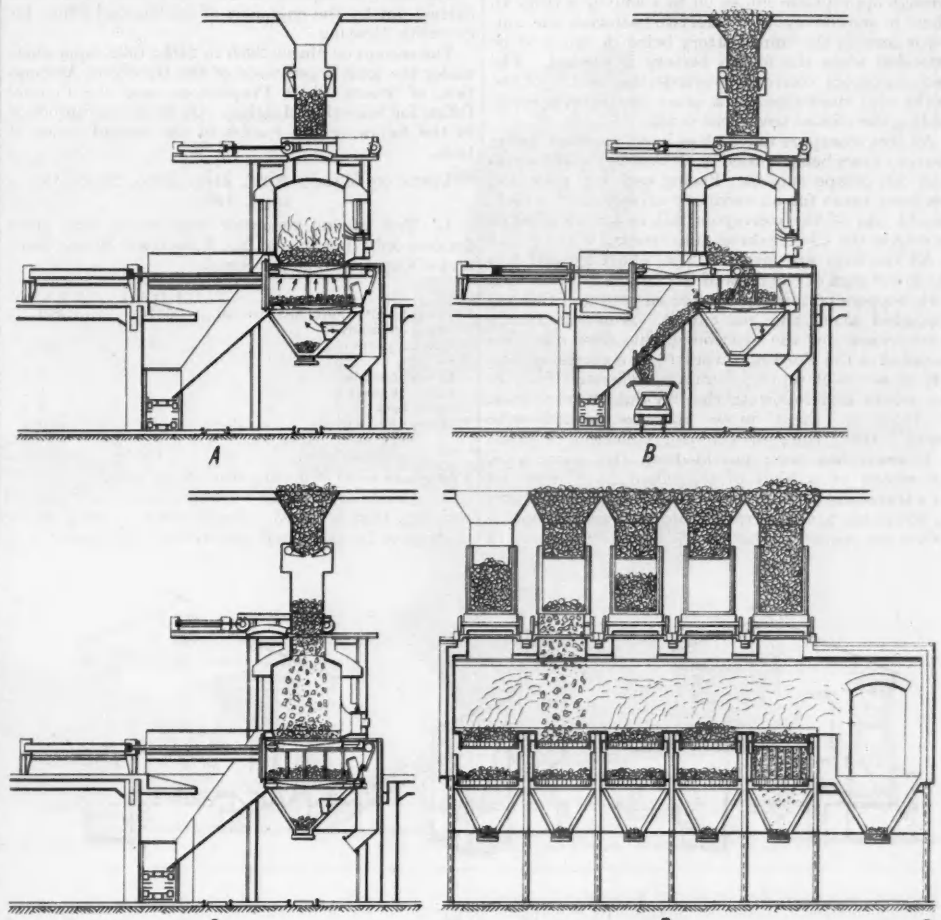


FIG. 2—DIAGRAM TO SHOW OPERATION OF REFUSE DESTRUCTOR FURNACE

arranged under the clinkering grates are built of sheet steel, with a suitable lining of masonry. At the side of these clinker hoppers there is an air duct running through the whole furnace block and having connections to each individual grate section, which is provided with a regulating valve. There is, connected to each furnace unit, the forced draught fan delivering 425 cubic metres per minute, to supply the air of combustion against a pressure of 70 mm. water gauge up to 200 mm. water gauge. The charging and clinkering actions of each grate section are hydraulically operated by special hydraulic cylinders working at a pressure of 100 atmospheres. The charging cylinders have a length of stroke of 1100 mm. and an inside diameter of 65 mm., while the stroke of the grate cylinders is 2450 mm. and their inside diameter 110 mm. The charging and grate cylinders, as well as the regulating valve for the supply of air of combustion, are controlled from a convenient position on the clinkering floor at the side of each grate.

The combustion chamber, which runs over the interconnected destructor cells, is extended by a flue which is connected to the front of the boilers (Fig. 4) above the mechanical grates, and delivers over their entire width a layer of destructor gases, the flow of which is guided and regulated by distribution pillars judiciously arranged.

The destructor gases thus delivered above the coal grates actually have an apparent density greater than that of the gases from coal combustion—not owing to their specific gravity which, on the contrary is lower, but owing to their temperature which is considerably lower. As a result thorough mixing of the two kinds of gases is obtained and their complete combustion is thereby assured. The frame of the boiler has been specially designed to take the thrust of the arch of the flue conveying the refuse gases. The girder which bears this thrust is protected at its bottom part by a flat arch situated in front, above the gas inlet and connected to a system mainly consisting of two square steel boxes. These boxes are in communication with the boiler drums and are constantly cooled by the water circulation. Each boiler is fitted with two mechanical stokers 2130 mm. wide, with a length of of 4270 mm. Two forced draught fans are fitted to each boiler, designed for a pressure in the pressure pipe of 100 mm. water gauge. These fans are installed in the basement of the plant. The steam boilers installed, of which there are three in the complete plant, have a heating surface of 600 square metres each. They are of the inclined water-tube type, each with three boiler drums and one superheater with a heating surface of 250 square metres. The boiler pressure is 25 atmospheres and the steam superheat required is 375 deg. Cent.

Each unit, by direct firing on the mechanical grates alone, provides an evaporation of 18,000 kilog. per hour, with a mixture of 80 per cent. coke dust and 20 per cent. fine Cardiff. The hourly evaporation may reach 24,000 kilos. by burning small Cardiff from which the dust has been removed. Slowing down to 9000 kilos. per hour is resorted to if necessary. If destructor gas alone is used, the evapora-

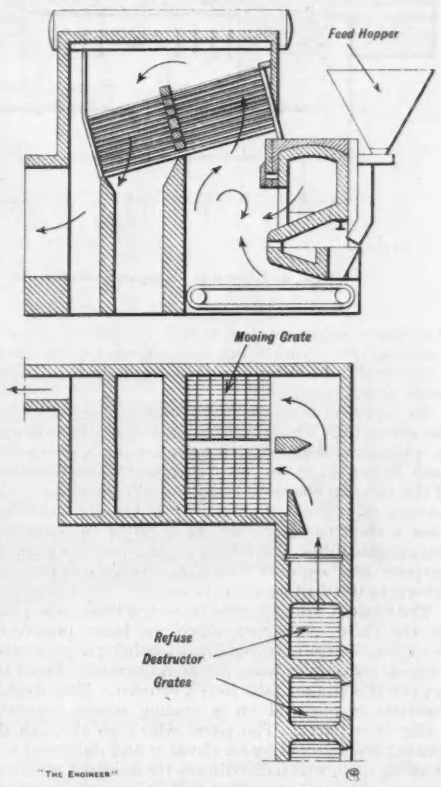


FIG. 3—ARRANGEMENT OF DESTRUCTOR FURNACES AND BOILERS

tion varies according to the quality of the refuse and the rate of combustion, from 2400 kilos. to 8200 kilos. per hour, with from 375 deg. to 400 deg. superheat. Mixed firing with destructor gas and mechanical grate gases is a normal procedure in winter for five

hours a day to enable the power station to meet the peaks. It provides for the evaporation of 18,000 kilos., at 390 deg. or 400 deg. of superheat, whatever may be the quality or quantity of refuse burnt.

The clinker ejected from the grates of the refuse furnaces by the operation of the scraper rakes falls through appropriate chutes on to a conveyor (Fig. 4). There is one conveyor for each two batteries, the conveyor serving the third battery being designed to be extended when the fourth battery is erected. The two conveyors converge towards the centre of the works and discharge on a cross conveyor, directly feeding the clinker treatment works.

All this transport takes place in an enclosed space, the conveyors being housed in tight casings, so that no dust can escape outside. Facing each cell provision has been made for an auxiliary arrangement which, should one of the conveyors fail, makes it possible to deliver the clinker direct into trucks.

All the flues are situated 2 m. above ground and the lower part of the flues of the boilers are provided with hoppers permitting the accumulation of fine ash deposited along the gas circuit. A new hydraulic arrangement for the ejection of flue dust has been installed in the Bordeaux works. It consists essentially of a net of piping, running under the floor of the works and following the lay-out of the flues. If required, these pipes can be flushed with water. Over each of the ash collecting hoppers a hydrant has been provided on the water pipe. By means of a kind of telescopic hose mounted on a travelling frame the lower part of the hopper can be connected to the corresponding hydrant; then the valves are opened so that all the dust accumulated in the hopper may be carried away by the flush water to a settling tank, from which the ash, after being dried, is removed. All these arrangements help to keep the works free from dust.

To complete the provisions made, a fan draws out the refuse dust from all those points at which it may be present and delivers it into an easily accessible hose filter. It is in this manner that the edges of the furnace charging hoppers are connected to the suction piping of the fan. It is usually sufficient, once a day, to shake the filter hoses to make the accumulated dust fall into a hopper provided for the purpose and capable of being connected, like the others, to the dust suction system.

The clinker, brought directly to the treatment plant by the third conveyor, which we have previously described, is first delivered into a receiving hopper fitted with an automatic watering arrangement. From the hopper the clinker falls into a crusher. The crushed material is received on a grating which separates bulky iron parts. The parts which go through the grating are handled by an elevator and delivered to a shaking tray, which distributes them into a revolving screen. The latter separates it in four grades: 0–10, 10–20, 20–40, and residue above 40. In eight hours the plant is capable of treating the clinker produced by the daily burning of 400 tons of refuse. The bunkers arranged under the revolving screen allow for the storage of each grade of clinker produced during two days' running of the plant. They are arranged so that by means of chutes lorries can be loaded directly. A special hydraulic press packs the old metal collected.

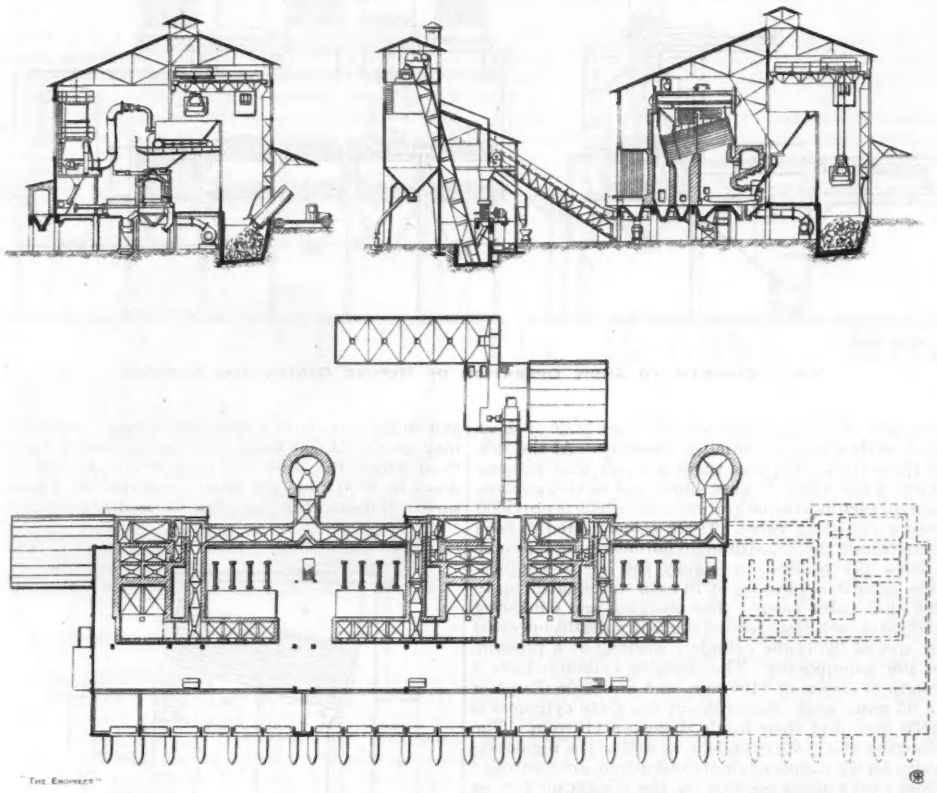


FIG. 4—GENERAL ARRANGEMENT OF BORDEAUX REFUSE DESTRUCTOR PLANT

TESTS AND RESULTS.

The Bordeaux refuse destructor works have undergone two series of tests by independent authorities:—

The first, on September 14th and 15th, 1933, were carried out by the engineers of the Central Office for Scientific Heating.

The second on March 20th to 24th, 1934, took place under the joint supervision of the Bordeaux Association of Steam Plant Proprietors, and the Central Office for Scientific Heating. Of these we reproduce in the following the results of the second series of tests.

TESTS ON MARCH 20TH, 21ST, 22ND, 23RD, AND 24TH, 1934.

1.—Test of one generator with mechanical grate for coal only (mixture of No. 1 gas coke, 80 per cent., and of Courrières, 20 per cent.).

	Results recorded by C.O.S.H.	B.A.S.P.P.
Lower calorific value of mixture, cal.	5276	5269
Thermal efficiency:		
Output, per cent.	81·1	82
Losses:		
Unburnt solids	2·6	2·4
Unburnt gases	1·2	1·2
Sensible heat	11·1	9·4
Radiation and various	4·0	5
	100·0	100·0

The guaranteed efficiency was 79 per cent.

2.—Combustion and evaporation test, mixed running, that is to say, simultaneous working of the destructor furnaces and mechanical coal grate.

The object of this test was to ascertain whether, with the destructor furnaces working normally, it would be possible with the coal grate to raise evaporation up to 30 kilos. per square metre; that is to say, 18 tons per hour, without interfering witht the working of the destructor furnaces. The test was made on one group, four destructor furnaces and their corresponding mechanical grate. The coal was of the same quality as for the previous test: 5464 calories (C.O.S.H.), 5327 (B.A.S.P.P.) of lower calorific value. Rate of burning for one hour:—House refuse, 4·425 tons, or 65·5 per cent.; coal, 2·330 tons, or 34·5 per cent.

The following table shows the results obtained:—

	Results recorded by C.O.S.H.	B.A.S.P.P.	Guaranteed figures.
Calorific value of refuse	1666		1500
Rate of refuse burning p.h., tons	4·425	4·425	4
Rate of coal burning p.h., tons	2·320 at 5464 cal.	2·333 at 5327 cal.	1·960 at 6240 cal.
Rate of evaporation per hour on the agreed conditions:			
Feed 50 deg., pressure 25 kilos., superheat 375 deg. tons	19·060	19·665	18
Actual superheat, deg.	413	399	375
Temperature in combustion chamber, deg.	977	992	900
CO_2 in combustion chamber, per cent.	10·8	11·3	10
CO_2 outlet of boiler, per cent.	11·8	12·0	10

3. Test of combustion and evaporation with refuse only. Duration of test, 17 hours 24 min. 15 sec.; battery under test, battery No. 2 of four cells; quantity of refuse destroyed, 77·010 tons (instead of 72·500 tons guaranteed).

	Results recorded by C.O.S.H.	B.A.S.P.P.	Guaranteed figures.
Average analysis of refuse treated:			
Water	32·2	34·3	20
Ash	32·2	39·5	
Carbon	23·4		
Hydrogen	1·9		
$O_2 \div N_2$	10·3		
Calorific value:			
Higher on gross, cal.	1925		
Lower on gross, cal.	1666	1762	1200

The analysis and percentage of refuse was determined by taking 566 kilos. of refuse at the rate of one pailful for each filling of charging hopper.

	Results recorded by C.O.S.H.	B.A.S.P.P.	Guaranteed figures.
Rate of refuse burning per hour, tons	4·425	4·425	4
Evaporation (under agreed conditions:			
Feed 50 deg. pressure 25 kilos, superheat 375 deg. per hr., tons	5·929	5·847	4
Per ton of refuse burnt, tons	1·340	1·321	1
Actual steam pressure, kilos.	20·7	20·7	
Actual steam superheat, deg.	351·7	365·4	
Temperature outlet of boiler, deg.	273		
Temperature outlet economiser, deg.	175		
Temperature combustion chamber, deg.	965	967	> 700
CO_2 in combustion chamber, per cent.	10·85	11·8	10
Material collected from burnt refuse:			Say about
Ash, kilos.	1,612	1,610	2·1%
Iron, kilos.	1,602	1,602	2·1%
Clinker, kilos.	27.659	26,876	35%

Distribution of above Recovered Material.

	Kilos.
Ash:	
Under combustion chamber	986
Under furnace hoppers	402
Under boilers and flues	224
Total	1612
Clinker:	
At magnetic separator	1699
After crushing	
0·10	7,571
10·20	7,935
20·40	5,454
Residue	5,000
Total	27,659
Thermal efficiency (calculated by C.O.S.H.)	56·1%

4.—Combustion test on the three furnace batteries simultaneously burning refuse only.

Evaporation was not measured during this test because one of the batteries was by-passed; the total steam produced could not be absorbed.

Mixed refuse was burnt (including market refuse), per hour, 17·162 tons instead of 12 tons guaranteed; or per battery hour, 5·722 tons instead of 4 tons guaranteed.

For the works this was equivalent to a total destruction of 412 tons per twenty-four hours, whereas the guarantee was 300 tons.

Power Consumption.—The works power consumption was measured during this test.

	kWh per ton of refuse burnt.
For all the services of the destructor plant proper (but excluding boiler feed) the power consumption is	4·61
Consumption for boiler feed may be estimated at	1·6
Total	6·21

ONE would have expected that the opening of the Mersey Tunnel would have had some adverse effect upon the business done by the Mersey Railway. The receipts of the latter for the year 1934 from ordinary passenger traffic were £177,441, as compared with £173,111 in 1933, and the number of passenger journeys was 14,843,211, as against 14,389,043. It is a good sign that workmen increased in number from 2,421,664 to 2,653,016. In making these remarks we are aware that, at present, there are no regular passenger transport services through the tunnel, *e.g.*, by omnibus, but many who used to go to Birkenhead and the Wirral Peninsula, and *vice versâ*, by rail now go by motor car through the tunnel.

THE final attendance figures for the British Industries Fair which closed in London on Friday last, March 1st, showed that 27,273 more people visited the Fair than last year. The figures are 188,156, compared with 160,883 in 1934. The number of home buyers was 135,320, an increase of 20,981; of overseas buyers, 11,713, a decrease of 295, and of the general public 41,123, an increase of 6587. The apparent decrease in the number of overseas buyers, who attended the Fair from seventy-six countries, is explained by the fact that last year the Engineering and Hardware Section of the Fair was held at the same time as the Fair in London. This year it opens at Castle Bromwich on May 20th; it is therefore highly satisfactory that already the number of overseas buyers who have visited the Fair in London should very nearly have reached last year's total for the Fair as a whole.

TWO LARGE GERMAN MACHINE TOOLS

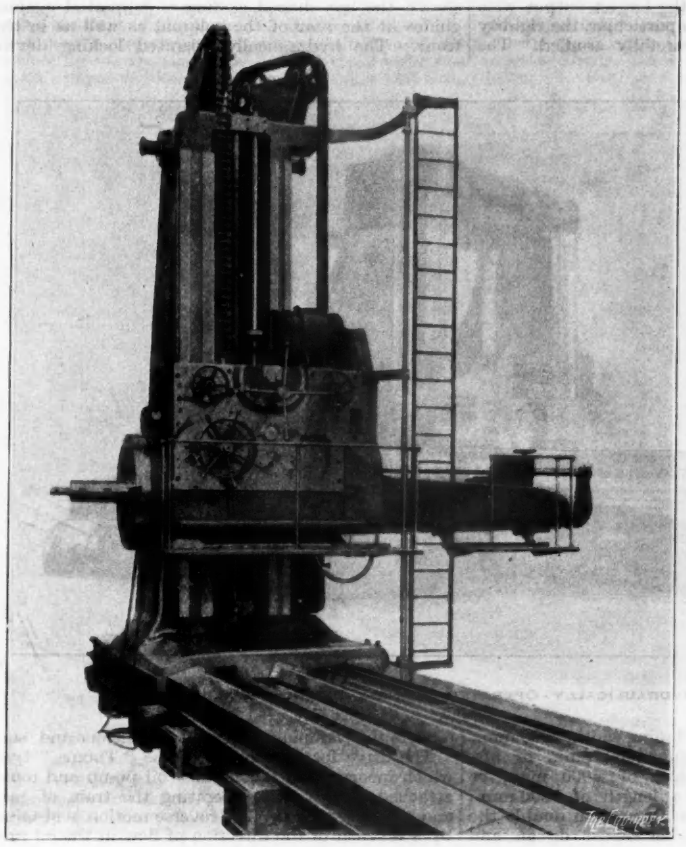


FIG. 1—HORIZONTAL BORING AND DRILLING MACHINE—COLLETT

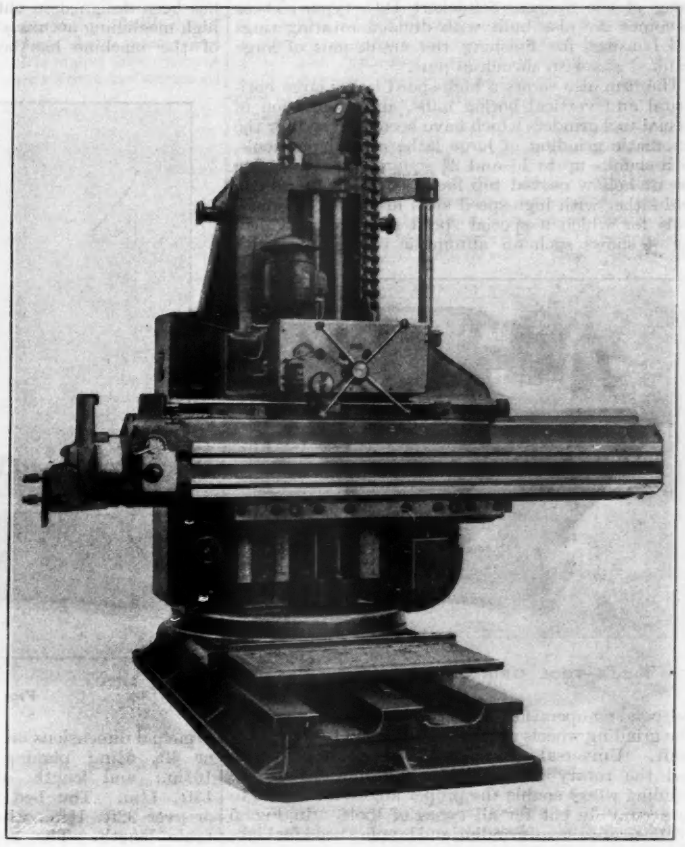


FIG. 2—PORTABLE SHAPING MACHINE—COLLETT

Leipzig Technical Fair.

No. I.

THE Leipzig Technical Fair, which was officially opened on Sunday, March 3rd, and will remain open till March 10th, shows by its increased size and the larger number of visitors from foreign countries, the remarkable recovery in German industry, which has taken place during the past year, despite the difficulties of tariffs, uncertain money values, and financial restrictions, all of which have tended to limit international trade and commerce. The space booked shows an increase of about 40 per cent. over the Spring Fair of 1932, and of 75 per cent. over that of the year following; while the total space booked is well over 431,000 square feet, compared with about 321,000 square feet in 1932. Arrangements for extensions next year are already being planned. Last year some 160,000 buyers visited Leipzig, of which about 10 per cent. came from seventy-two countries outside Germany. This year the number of visitors from foreign countries has risen by about 50 per cent. Special meetings have been arranged in order to bring foreign engineers into direct touch with the firms and trade associations desirous to export German engineering products. Other conferences deal with "Pressed Materials for Building and Insulating Purposes," "X-Ray Testing in Engineering Practice," "Foundry Work and Problems," and "Fine-finishing Methods, including the Machining of Light Alloys."

A noteworthy feature of the recent State organisation of industry in Germany is the grouping and subgrouping of the various branches of engineering industry which is now taking place, and which, it seems, is already resulting in a trend towards further standardisation of designs and materials, with improved quality and finish.

THE MACHINE TOOL EXHIBIT.

As in previous years, the principal attraction of the Fair is the very fine collection of machine tools, shown under operating conditions. Although some of these machines were shown at the recent Olympia Exhibition, the display as a whole is of more than usual interest on account of several examples of very large tools, which, although a feature in the 1925 Exhibition when Hall No. 9 was opened, and in the years following, have not been seen during the years of depression. It may be recorded that this year shows a return to the number of exhibits associated with the best period of the Fair. It was found difficult to accommodate all the firms which desired to exhibit in the No. 9 Hall belonging to Maschinen-Schau G.m.b.H., of the German Association of Machine Tool Manufacturers. The space was further limited by the decision of the Association to place all the stands on the ground floor, and to do away with the exhibits formerly placed in the somewhat narrow side galleries. This year these galleries are used to display a very interesting collection of instruments used for the measuring and recording of power, heat, pressure, and temperature, and apparatus employed in laboratory and works testing.

Next year, we were given to understand, it is the intention to make use of both Hall No. 9 and the adjacent No. 8 Hall for machine tool exhibits, a plan which should allow space both to old and new exhibitors and give increased opportunity for foreign exhibits to be staged. There also seems some likelihood of discussions taking place between British, American, and German machine tool firms, with the ultimate object of arranging technical exhibitions which would probably take place in successive years in London, Leipzig, and Cleveland, and would thus at three-yearly intervals serve to bring out the special features of each country's designs and productions.

SOME LARGE MACHINE TOOLS.

One of the largest exhibits is the heavy crank pin turning lathe illustrated by Fig. 3, which is to be seen working on the stand of Schiess-Defries A.G., of Düsseldorf. It is a new design of the type of tool which the firm constructs in ten sizes from a 20in. up to a 10ft. 8in. turning gap. The machine herewith illustrated has a turning gap of 2100 mm., or about 6ft. 10⅔in., with a total bed length over the two steadies and auxiliary steady, of 7000 mm., or nearly 23ft., with a breadth of bed of 2300 mm., or about 7ft. 6½in. Special attention has been given to the guiding and lubrication of the rotating ring, which carries the two tool slides, and a very satisfactory solution has, we are informed, been found. The whole of the machine is automatically lubricated, and a light control on the instrument board shows when the oil system is in operation. Other instruments

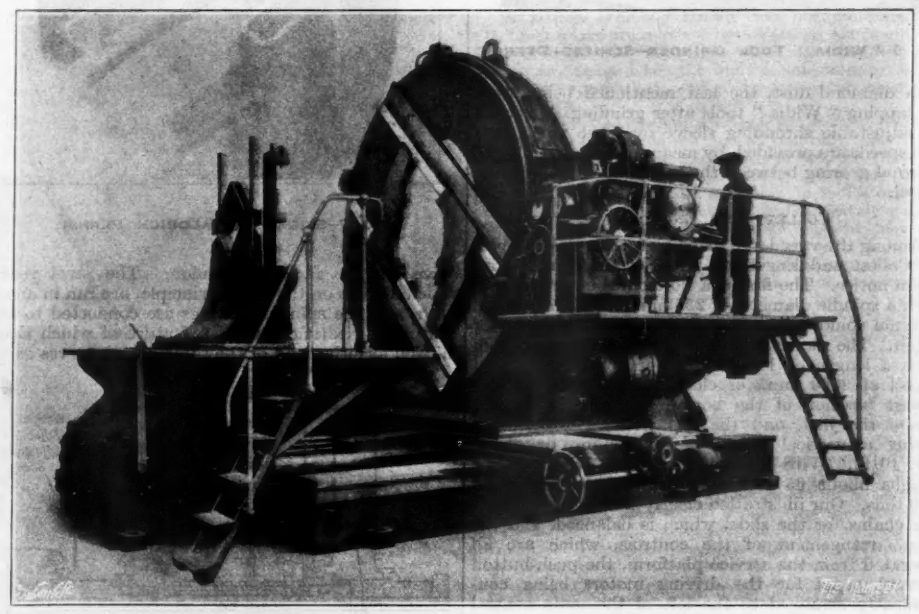


FIG. 3—CRANK PIN TURNING LATHE—SCHIESS-DEFRIES

include an ammeter to indicate the load and a speed indicator. The controls for the various motions are centralised, and the push-button system is adopted. Three separate driving motors are employed, these being of the Siemens-Schuckert D.C. type. These machines are also built with divided rotating rings and housings for finishing the crank pins of large crank shafts with shrunk-in pins.

The firm also shows a high-speed lathe, large horizontal and vertical boring mills, and a selection of special tool grinders which have been designed for the automatic grinding of large lathe and planer tools, with shanks up to $1\frac{1}{4}$ and $2\frac{3}{8}$ square section, having flat or hollow curved top faces. The machines can deal either with high-speed steel insets or "Widia" tools for which a special speed range is provided. Fig. 4 shows such an automatic tool grinder with

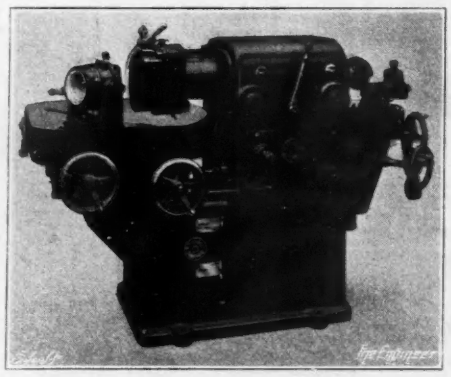


FIG. 4—TOOL GRINDER—SCHIESS-DEFRIES

independent operation of the two sides of the machine. The grinding wheels are directly coupled to the motor shaft. Universal clamping heads are provided, and the rotary and reciprocating motions of the grinding wheel enable the proper angles and rakes to be accurately cut for all types of tools. In Fig. 5 we illustrate a small grinding and lapping head for high-speed steel and "Widia" tools. The grinding wheel, which is about 6in. diameter, with a face of 2in., may be made of carborundum, silica carbide, or bakelite

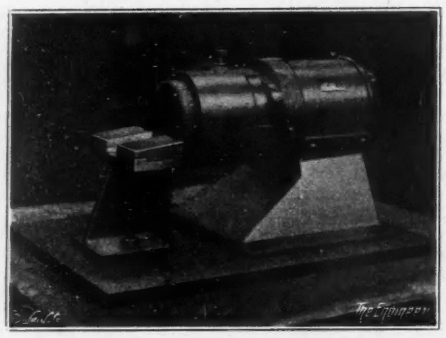


FIG. 5—"WIDIA" TOOL GRINDER—SCHIESS-DEFRIES

with diamond dust, the last mentioned being used for lapping "Widia" tools after grinding. There is an adjustable shrouding sleeve over the wheel and two speeds are provided, by means of a simple form of internal gearing between the motor and the grinding wheel.

COLLETT AND ENGELHARD.

Among the very large machine tools, two examples by Collett and Engelhard A.G., of Offenbach-Main, claim notice. The first is a horizontal borer (Fig. 1) with a spindle diameter of 225 mm., or $8\frac{13}{16}$ in., and an internal spindle diameter of 85 mm., or a little over $3\frac{5}{16}$ in. The machine is shown on a half-length bed, with a length of 11,200 mm., or 36ft. 9in., and a travel of 8000 mm., or close upon 26ft. 3in. The lowest position of the boring spindle is 750 mm. above the bed, and the top position 3750 mm., giving a vertical travel of 3000 mm., or about 9ft. $10\frac{1}{2}$in. With the half bed shown, the machine weighs about 65 tons, or with the complete bed 120 tons. Our illustration clearly shows the supporting chains for the slide, which is balanced, and the neat arrangement of the controls, which are all operated from the service platform, the push-button control panel for the driving motors being conveniently arranged to the left of the main control hand wheel. The machine is built for a large steel foundry and engineering works.

Our adjoining illustration, Fig. 2, shows a transportable horizontal planer or shaping machine of neat design, which has a stroke of 1400 mm., or 4ft. $7\frac{1}{8}$in., and a height of the same dimensions. It has been specially built for turbine and generator work, and is one of several such tools recently supplied to a large electrical engineering firm in Germany.

H. A. WALDRICH.

Among the very large planing machines exhibited at the Leipzig Fair we have chosen for description a new type of heavy-duty hydraulically operated planing machine, designed and built by H. A. Waldrich G.m.b.H., of Siegen, in Westphalia. A general view of the tool is reproduced in Fig. 6. It has been designed to obtain the largest output with high machining accuracy. In particular, the rigidity of the machine has been carefully studied. The

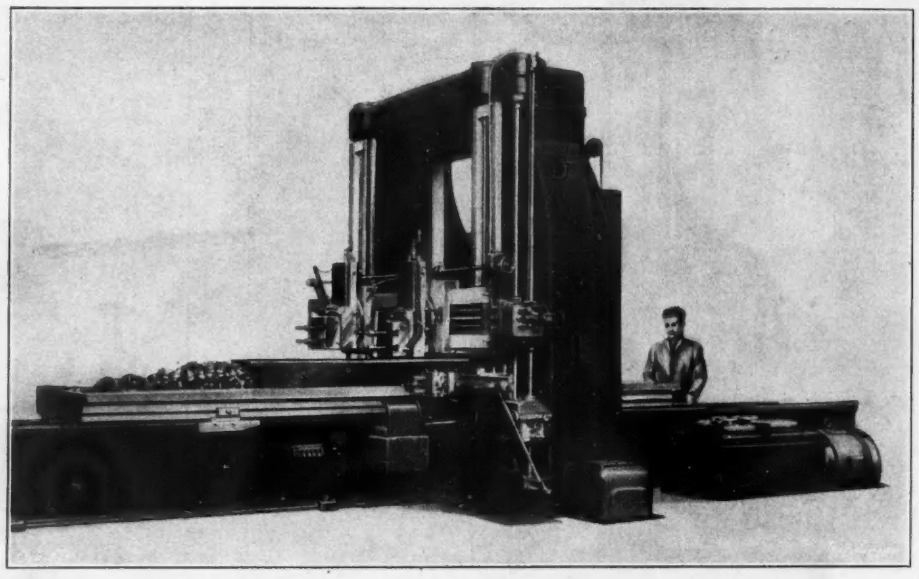


FIG. 6—HYDRAULICALLY-OPERATED PLANING MACHINE—WALDRICH

principal dimensions are:—Planing width, 2000 mm., or 6ft. $6\frac{3}{4}$in.; planing height 1800 mm., or 5ft. $10\frac{7}{8}$in.; and length of travel of 4000 mm., or 13ft. $1\frac{1}{2}$in. The bed has a length of 9800 mm., or over 32ft. $1\frac{3}{4}$in., which is more than double the table length. The bed is of robust design and is well ribbed, and carries within it the gear

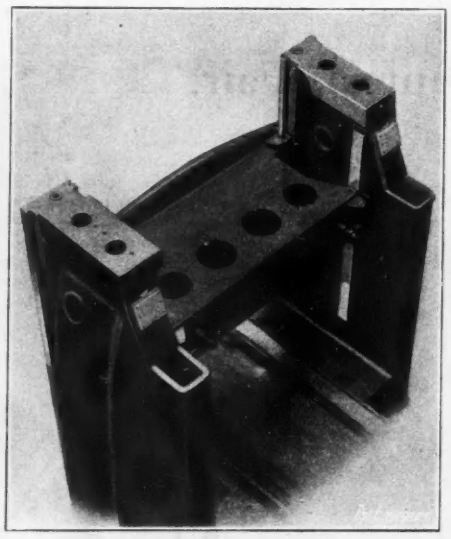


FIG. 7—SLIDE OF WALDRICH PLANER

drive for the rack and pinion. The steel gears, which are cut on the Maag principle, are run in an oil bath, and the spindle bearings are connected to the central lubricating system, a feature of which is an oil well at either end of the table, which serves as an

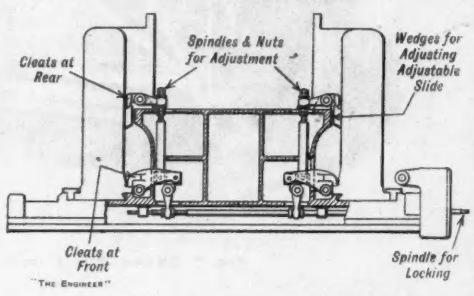


FIG. 8—SLIDE LOCKING DETAILS

oil sump and delivers the surplus oil back to the pressure system, which includes a pump with a strainer and filter and gives pressure feed to the slides. Attention may be drawn to the special constructions of the columns, slide, and top bridge, which are illustrated by Figs. 7 and 8. The designs adopted have resulted in a tool possessing great rigidity, even when taking the heaviest cuts with Widia and high-speed steel tools. The patented design of slide is characterised by its depth between the columns, which prevents any twisting or bending. As Fig. 7 shows, the box-shaped casting is supported against guides at the rear of the column, as well as in the front. The hydraulically operated locking device renders the clamping motion instantaneous and sure.

The drive for the rack is of the "Thoma" type, which incorporates a combined oil pump and motor attached to the shaft operating the train of gears and the rack pinion. The reverse motion is obtained by a reversal of the direction of flow in the oil pressure pump. The table speed can be regulated continuously over a wide range, and press-button control is also provided.

Other new features include an improved traverse mechanism, which gives a range of 5 mm. to 15 mm. per stroke, while the speed of the table can be controlled between 4 m. and 4·5 m. per minute. The slide is equipped with quick vertical and horizontal traverse motions. Micrographs of the cuts taken reveal very steady cutting, entirely free from tool chatter. The firm is also exhibiting under working conditions a 500 mm., or $19\frac{11}{16}$ in., centre heavy-duty, high-speed roughing lathe, which will take work 1000 mm., or $39\frac{3}{8}$in., diameter over the bed and 720 mm., or over $28\frac{5}{16}$in., over the supports.

(To be continued.)

THE ENGINEERS' GERMAN CIRCLE.

A NOTEWORTHY lecture was given at the meeting of the Engineers' German Circle on Monday evening, March 4th, at the Institution of Mechanical Engineers by Herr Adolf Meyer, director of the Brown Boveri Company, of Baden, Switzerland, on the "Velox" boiler.

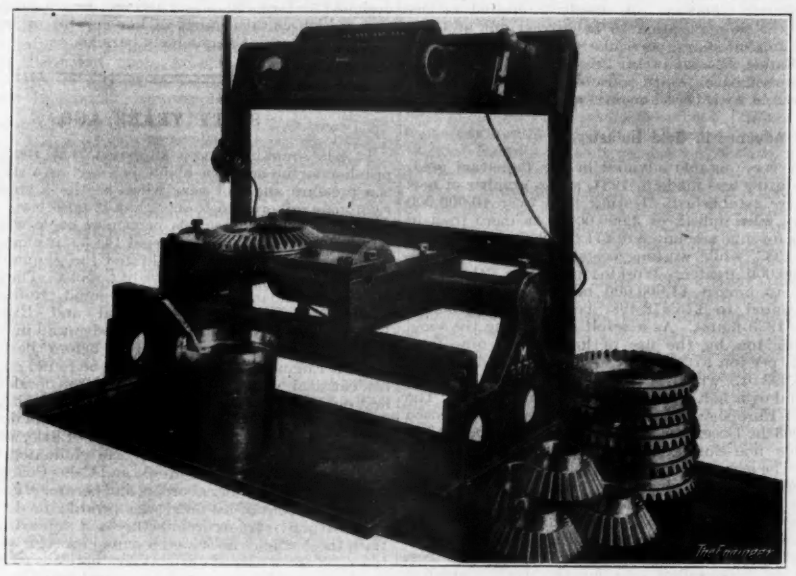
Herr Meyer dealt more particularly with the applications of the "Velox" boiler for land and marine purposes, and outlined some interesting proposals for the future development of this novel form of generator. He first described with the aid of lantern slides its principle of operation, laying stress on the thermo-dynamic and practical advantages resulting from the very high flue gas velocity employed and the disposition of the gas turbine between two heat-absorbing parts of the boiler. He then showed by a series of comparative diagrams the saving of space effected by the "Velox" boiler over boilers of the ordinary type, and even of modern special types for the same output. Next he illustrated some land power installations at Copenhagen and Toulon, and a proposed one-room "Velox" central station, showing how this type of plant is especially appropriate for sudden peak loads. After illustrating a blast-furnace gas installation at Mondeville, and some noteworthy central heating "Velox" plants, he showed a number of proposed schemes for the application of the boiler to locomotives and ships. In both cases comparison was made with corresponding oil engine installations rather than with the conventional steam types, since Herr Meyer claimed that the "Velox" boiler afforded a means whereby steam might retain the special fields of application now being encroached on by the oil engine. In the ensuing discussion, Herr Meyer said that successful experiments were in progress with the use of pulverised fuel in the "Velox" boiler, but that it was too soon as yet to offer such a boiler for sale. The lecturer was accorded a very hearty vote of thanks. The audience numbered eighty members and visitors. After the meeting members and guests adjourned to the D'Abernon Club, 6, Carlton-gardens, for supper and German conversation.

THE L.N.E.R. locomotive "Cock o' the North" returned from France to England a few days ago after tests on the locomotive-testing plant at Vitry.

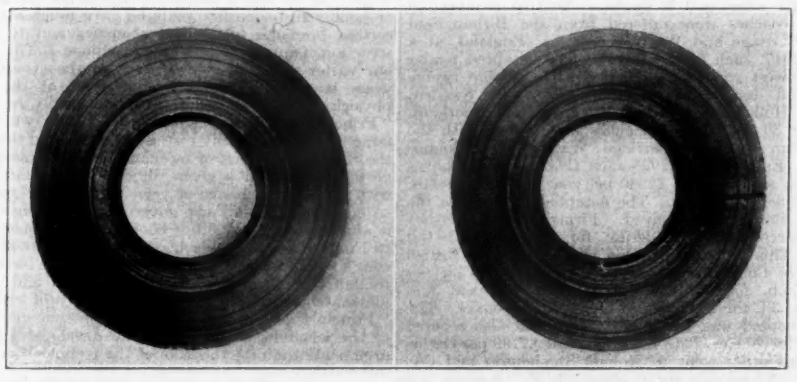
Inspection of Engine Components by the "Magna-Flux" Method.

IN the inspection system applied by the Bristol Aeroplane Company, Ltd., to the manufacture of "Bristol" aero-engines, two methods of examining components for surface defects are employed—first, by visual inspection of the component after it has been etched in an acid bath, and, secondly, by the "Magna-Flux" method which reveals cracks by the concentration of iron particles under the influence of a magnetic field. Etching is used extensively for the inspection of all components, including those of non-ferrous and non-magnetic materials, since it readily shows up flaws and non-metallic inclusions which are beyond the scope of the Magna-Flux method.

In the case of steel components, the Magna-Flux method is supplementary to the etching method, and is, moreover, particularly useful in showing up quite small surface cracks, caused either by original material defects or produced or revealed by subsequent heat treatment or manufacturing operations, which are difficult to see after etching. This method is applied extensively to a number of important engine components, not only at certain stages of manufacture, but also after periods of running in an engine. Highly stressed components, in particular, are subjected to this method of inspection, including various gears and driving elements in the air screw reduction gear, reduction gear driving shaft, crank shaft, master and articulated rods, gudgeon and articulated pins, various driving elements in the supercharger drive, and numerous other auxiliary driving gears and shafts. Since it is in the detection of small cracks which appear under severe running conditions that the Magna-Flux method of inspection is particularly useful, it is applied extensively to components of new production engines after their first endurance tests, to engines returned for repair or overhaul after some period of service, or type test, and to experimental or development engines which are undergoing severe testing and overload running at the Bristol works. This application reveals any weakness which may develop in the components under exceptionally severe conditions of running, as a result of either incorrect design or faulty material.



THE MAGNA-FLUX TESTING EQUIPMENT



VALVE COLLAR BEFORE AND AFTER TESTING

REDUCTION GEAR WHEEL BEFORE AND AFTER TESTING

The Magna-Flux method enables the examination to be made comparatively quickly, especially, for example, in the case of components such as gear wheels, where a microscopic search for defects necessitating the careful exploration of each tooth would occupy a long time. The actual method of carrying out the test is very simple, and requires no particular skill, since any cracks are plainly shown up, as may be seen from the two examples illustrated herewith. The apparatus itself, which is supplied by the Equipment and Engineering Company, of London, consists of a large coil energised by direct current and incorporating a solid core and adjustable sliding pole pieces, across the gap of which the component under test is placed. The intensity of the magnetic flux is controllable, since too much magnetism will smother a crack and too little will fail to reveal it. In addition, the magnetic flux may be reversed to allow the component to be removed from the machine and also to disperse any residual magnetism that may have been imparted to it. The component, freed from grease, oil, and carbon, is placed on the pole pieces in such a position that the field of force will be at right angles to the expected crack. With the current switched on, a liquid containing minutely divided iron particles, called "detector ink," is poured gently over the component with the aid of an aluminium ladle, and any cracks are revealed by the accumulation of the iron particles on the edges, through the local disturbance of the magnetic flux. A crack will always be sharply defined, and may be quickly confirmed by a second test.

DE-MAGNETISING EQUIPMENT

After aero-engine components have been subjected to this treatment in an intensive magnetic field, it is of great importance that all residual magnetism within them shall be dispelled. This de-magnetising process is effected by passing the components through a field of a de-magnetising coil, which is energised by alternating current. Any parts of irregular shape, such as gears, are turned round whilst in the field, so that all the various portions are properly subjected to the de-magnetising influence.

The Design of Safe Load Indicators.

IT is now generally known that jib cranes used on building works are required by a Factory Act Regulation to be fitted with indicators which automatically give a warning signal when the limit of safe working at any radius is approached, and a danger signal when it is exceeded.

This regulation has been coming into operation gradually since 1931, and during the current year only these cranes are exempt which were manufactured between December 31st, 1921, and January 1st, 1932. After the current year no jib cranes will be exempt. An indicator, to be satisfactory, must signal clearly and decisively and, of course, correctly, and with complete reliability not only during a test when the crane is moved with the utmost gentleness, but under working conditions and at working speeds. Indicators complying with these requirements not only increase the safety of working, but also increase the speed of working with safety. That such indicators are being appreciated by engineers is clearly shown by the fact that indicators are now fitted to many cranes which do not come under the regulations.

A grave defect in many indicators is a tendency to oscillate under the shocks of ordinary working so that the signal flickers from "safe to danger" under a safe load, and from "danger to safe" under a dangerous load, and the driver cannot tell the difference unless he moves the load slowly and gently, which is obviously incompatible with speed. Many indicators are in the nature of spring balances, and special precautions must be taken if oscillation is not to occur. In one type, described on another page of this issue, the difficulty is surmounted by making use of a compression strut instead of a spring.

A matter that must be taken into consideration in applying an indicator to a crane is friction in the crane itself affecting the member which is to operate the indicator. If, for instance, this member be the lifting rope, the pull in the back lead of this, *i.e.*, the part between the jib head pulley and the winch, is greater when being pulled inwards over the pulley to lift the load than when being paid out to lower it. If an indicator be fitted to be operated by the back lead of the lifting rope and is set to signal just when the limiting load is being lifted, the signal will change when the movement of the load is changed to lowering because the pull in the back lead is then decreased. Lowering out the jib causes the lifting rope to be pulled over the jib head pulley in the same direction as lifting the load, and this action also increases the pull in the back lead. The back lead of the lifting rope

is thus very suitable for operating an indicator, because on any movement of the load towards danger the frictional effect tends to bring the danger signal on and any movement towards safety tends to make the danger signal cease. Friction generally acts in the opposite way when an indicator is operated by the standing end of a rope, and the effect is that the indicator may signal danger when perfectly safe loads are being lowered. This is very noticeable in some cases in which the indicator is operated by the reefing gear of such cranes as Scotch derricks. In these cranes the back lead of the lifting rope is comparatively close to the reefing gear and contributes considerably to the support of the jib under load. When the load is being lifted the pull of the lifting rope over the jib head pulley tends to lift the jib and thus reduce the pull in the reefing gear, and when the load is being lowered the pull in the reefing gear is thereby increased. Since the indicator must be set to signal when the maximum safe load is being lifted, a great deal of bell ringing occurs, when perfectly safe loads are being lowered. This result is very irritating to the driver and breeds a disregard for the signals, so that the indicator ceases to be a safeguard. It is liable to exhaust the indicator batteries very quickly if they be used to operate the signals, and so put the bell out of action.

Apart from the effect of ordinary friction on the working of an indicator, the effect of extraordinary friction—such as a partial seizure—should be considered. If the indicator is fitted so that the friction during lifting the load tends to bring the danger signal on any increase in friction simply results in an early warning being given. If friction operates in the opposite way, as in the case of indicators operated by the reefing gear of Scotch derrick cranes, the effect may be to put the indicator out of action altogether. The above contingency may be considered to be a very remote one, but if an indicator is to be relied on when the crane is worked at an increased speed, anything which may impair its infallibility is important. Another contingency in which an indicator operated by the back lead of the lifting rope is an effective safeguard is that in which the jib is lowered on to the overhaul weight of the lifting rope. This throws a very heavy overload on the lifting rope, which is immediately announced by the danger signal of the indicator. The pull in the derricking rope is, of course, reduced so that an indicator operated by it would give no warning.

The reefing gear is very commonly used for operating indicators, because it is usually a very simple matter to insert an indicator between it and its anchorage, and in many types of cranes it is excellently adapted to operate an indicator. In some cranes, however, it is quite unsuitable because of the frictional effect already described, and in other cranes it is unsuitable because the back lead of the lifting rope makes a large angle with the jib. Sometimes, indeed, the jib bisects the angle between the vertical and back lead of the lifting rope, and the weight of the load does not affect the pull in the reefing gear.

With regard to indicators themselves there is always a part of them which is moved by the force due to the load to operate a signal when the load has a value which should cause a signal. The force due to the load is usually great and the movement necessary to operate the signals is considerable. In most indicators the force is balanced by a spiral spring acting through a train of levers or other force-reducing and motion-multiplying gear. The great force reduction is necessary if the spring is to be of convenient dimensions, and all the gear between the rope applying the force and the spring is, of necessity, mounted on ball bearings or the like. These bearings must be kept scrupulously free from grit or moisture, and must therefore be sealed by means which do not themselves incur friction. In some cases a pendulum is used to regulate the indicator to signal different loads at different inclinations, and this must swing freely and without friction.

South African Engineering Notes.

(By our South African Correspondent.)

CAPE TOWN, Feb. 15th.

Diamond Mines Start Again.

THERE was great rejoicing at Kimberley on Monday, February 10th, when Sir Ernest Oppenheimer (chairman of the De Beers Company) announced at a luncheon given to delegates to the Imperial Press Conference at the Kimberley Club that when Lady Astor, wife of the President of the Conference, set the wheels of the great pulsator going that afternoon, it would not be merely a demonstration, but would be the restart of the diamond fields after three year's idleness. Sir Ernest Oppenheimer said he was sure the diamond fields would be prosperous again and would play their part in the development of the sub-Continent. They had been told that the diamond trade would never recover and that the fashion in diamonds had gone. This was not true. The world became poorer as the result of the great depression, and there was no money available for luxuries; but now diamonds were again in growing demand and the improvement was expected to continue. He added that the diamond was a great barometer of spending power.

Improved Transport Services.

Within this year the transport service of the cities of Johannesburg and Cape Town will be extensively reorganised and increased. The Cape Town Tramways Company has already purchased fifty trackless trams, or trollybuses, either name being used indifferently, for the sum of £112,000. Thirty of these vehicles will be double-deckers, carrying sixty-three passengers, and twenty will be single-deckers, carrying thirty-nine passengers each. The larger models cost £2400 each, and the smaller £2000 each. All the routes at present covered by rail trams will be operated by the new trollybuses, which will be put in service as they arrive from England, the first batch being expected to reach Cape Town in about six months. Johannesburg is preparing to reorganise its municipal transport services, and has sought permission of the Transvaal Provincial Administration to raise a loan of £191,630 for the purpose. The proposals involve important changes in the tramway and omnibus systems, and are based on the findings of the Commission of Inquiry, but there are one or two minor deviations from the suggestions in the Commission's report. The tramway system of Port Elizabeth is owned by the same company that operates the Cape Town system, and so it is probable, if the Cape Town new system turns out successful, that the Port Elizabeth system will be converted in the same way. Other municipalities at present running electric tramways are deeply interested in the success of the reorganisation to be carried out at Cape Town and Johannesburg, particularly Maritzburg (Natal), Durban (Natal), Bloemfontein, Pretoria, and several are already experimenting with various types of trams or omnibuses, and with Diesel engines and other types.

Great Advance in Gold Industry.

A very notable advance in the Transvaal gold-mining industry was made in 1934, and a number of new records were established. During 1934 over 40,000,000 tons of ore were milled, or 3,000,000 tons more than in 1933. The revenue amounted to £71,645,606, or £4,000,000 ahead of 1933, while working costs at £38,984,853 were over £2,800,000 greater. Working profits at £31,666,074 amounted to almost £1,000,000 more, while dividends paid amounted to £15,878,498, being over £2,000,000 above the 1933 figure. As a result of reducing the yield of gold per ton by the use of lower-grade ore—from 5·844 dwt. per ton to 5·15 dwt.—the total yield declined to 10,486,393 oz., which is over a million oz. less than in 1932, and over half a million oz. less than in 1933. The number of Europeans employed on the mines increased from 23,063 in December, 1931, to 30,000 in December, 1934, while non-Europeans increased from 213,419 to 260,000. The average recovery of gold for the Witwatersrand mine was 5·15 dwt. per ton, compared with 5·844 dwt. for 1933. One mine, the Van Ryn Estate, had a recovery for the month of August of 2·426 dwt., and made a profit of £9059, compared with £6643 in the same month of 1932, with a recovery of 4·411 dwt. Altogether, 1934 was an outstanding year for the world's greatest gold industry. It saw a record amount of nominal capital registered in the names of new and old companies, the total amount being £27,157,647, or double the amount registered in 1933.

New Railway Rolling Stock.

According to the Minister of Union Railways, since January 1st, 1933, orders have been placed for 50 railway coaches and 76 engines. Of that number, 20 first-class coaches were ordered from the Birmingham Railway Carriage and Wagon Company, England, at a cost of £2947, each f.o.b. erected. The accepted tender was the lowest with one exception. There were twelve unsuccessful tenderers, including firms in Sweden, Belgium, Holland, Germany, England, and Scotland. Orders for 30 second-class coaches were placed with the Metropolitan Cammell Carriage Wagon and Finance Company, England, at £2935 each f.o.b., for 10 coaches supplied in sections, and £2860 per coach for 20 coaches, f.o.b. completely erected. The accepted tender was the lowest of the twelve received. Firms in ten countries were unsuccessful in tendering for 50 class "19 C" engines. This order was placed with the North British Locomotive Company, Scotland, at £5716 16s. 3d. per engine, f.o.b. for 25 fitted with steel fire-boxes, and £5817 11s. 3d. for 25 fitted with copper fire-boxes. The tender accepted was the lowest. England also secured the order for 20 class "15 E" engines at £7789 per engine f.o.b. This order went to Robert Stephenson and Co., England. A contract for 6 class "16 E" engines was placed with Henschel and Sohn, Germany, at £6561 per engine f.o.b.

Electric Lamp Characteristics.

A PAPER on "The Time Characteristics of Tungsten Filament Lamps for Signs, Signals, and Beacons," was presented by Messrs. J. M. Sandford and J. H. Waldram at the February meeting of the Illuminating Engineering Society. The authors explain that, in special illuminating equipment, such as signals and beacons, in which it is necessary to produce a flashing indication by interrupting the lamp circuit, information is required relating to the time characteristics of the lamps used. Experiments have been carried out with fifteen lamps covering as evenly as possible the limits of current rating of 0–50 ampères, and incandescence and nigrescence curves were obtained to show the empirical relation of incandescence and nigrescence times and current rating, as well as the effects of rapid switching and external resistance.

The authors explain that the most straightforward application of the data obtained is to electric signs in the design of which the speed of nigrescence of the lamps used is often very important, particularly in signs simulating rapid motion. In some a high speed of nigrescence is desirable, and in others a low speed. A sign intended to represent a slow, gentle movement, such as curling smoke, requires quite long incandescence and nigrescence periods if a jergy effect is to be avoided, while "drifting" news signs, in which a series of letters is caused to drift across the face of a bank of lamps, require a very high speed of nigrescence, otherwise the letters appear to leave a trail behind them. The latest drifting signs, however, make use of small electric discharge lamps and the periods of incandescence and nigrescence are practically nil, with the result that a very sharp and clear indication can be given at any speed.

In dealing with communication by light signals, the authors explain that these vary from the transmission of fairly long messages to the broadcasting of one or two letters or numerals which convey an order or information acording to a recognised code, and the intensity distribution of the signal may vary from a very narrow angle beam to a signal extending over the complete hemisphere, depending on the service it is required to give.

The intensity of the light beam determines the characteristics of the lamp. The greater the solid angle of the beam the more flux will be required for a given range, and the greater will be the power of the lamp necessary. The smaller the solid angle of the beam, the smaller must be the filament of the lamp, and consequently the less the filament voltage, and for a given flux the greater the current. Narrow beam long-range signal projectors suitable for high-speed signalling cannot therefore be operated by keying the lamp circuit, and, in effect, for a given beam divergence the signalling speed sets a limit on the range. Wide-angle signal projectors can usually be designed for larger filaments and it is consequently possible to use high-voltage lamps of low current or lamps with several low current filaments in parallel.

SIXTY YEARS AGO.

IT has sometimes been supposed that there is some peculiar virtue or merit about 14½ deg. as a standard for the pressure angle of gear wheel teeth—a standard less rigorously adhered to to-day than it once was. Actually the initial reason why this particular angle was adopted was the very simple one that sin 14° 30′ is almost exactly equal to ¼, a fact which facilitated the geometrical work involved in laying out the form of a tooth. The originator of this standard was the Reverend Robert Willis, Jacksonian Professor of Natural and Experimental Philosophy at Cambridge. It was advanced in a paper on "Teeth of Wheels," which he read before the Institution of Civil Engineers in 1838 and is to be found embodied in his classical work entitled "Principles of Mechanism" first published in 1841. In our issue of March 5th, 1875, we recorded the death of Professor Willis on February 28th at Cambridge in his seventy-fifth year. Little, we said, was known of his early education. He graduated, however, as ninth wrangler from Gonville and Caius College in 1826. Although he took clerical orders and became a Fellow of his College the bent of his mind was towards the development of constructive art in architecture and applied mechanics. With these studies he shared a strong taste for archæology. Indeed if the writer of our obituary notice is to be trusted, the division of his mind's affections prevented him throughout his life from attaining the full position in mathematical science which his abilities qualified him to fill. He lacked perspective, so it was written, and spent much time over trifles. He was minute and accurate in all his thoughts and strove to make his students likewise. To that end he would occupy a whole lecture with a discussion of the proper relation between the cutting angle of a tool and the hardness of the material being cut or with the proper method of holding a carpenter's chisel on the grindstone or hone. In his earlier years he gave much attention to certain branches of applied acoustics and to the construction of automatic speaking machines. "This subject," our writer said, "occupied much of the attention some years later of Wheatstone and some of the German physicists but so far with little success." In his book "Principles of Mechanism," the work on which Willis' fame will always chiefly rest, he systematised the whole of the then known class of mechanical contrivances for converting motion in a given direction into that in others with or without change of velocity and developed a consistent system of formulæ governing the changes. Before it appeared the only other book on the subject available to English readers was a translation of Lantz and Betancour's "The Elements of Mechanics" a work which though copious was defective in method and devoid of kinematic formulæ. To-day we may still read Willis' "Principles of Mechanism" with profit but more because of the leisurely way in which he develops clear-sighted arguments than for the sake of the technical value of the information.

THE EVALUATION OF GLARE FROM MOTOR CAR HEADLIGHTS.*

MEANS of approach to the problem of glare from motor car headlights is provided by a report issued on March 4th by the Department of Scientific and Industrial Research. Many devices for getting rid of the glare of headlights have been proposed. A large number of them are unfortunately of no value. Some scientific method of analysing the contributing factors in glare is necessary, and is attempted in the report, in which a method is developed for calculating the reduction in a driver's ability to see objects on the road ahead, owing to the glare or dazzle from the headlights of passing cars. The method is based on extensive measurements of the effect of glare on vision, made partly in the laboratory and partly on the road. The extent to which the visibility of objects is reduced when two cars approach and pass depends upon the distribution of light in the headlight beams when the headlights are set for the passing condition (*e.g.*, for a dipping headlight it will be the light distribution in the dipped beam which is concerned). Given the passing beam distribution for any existing or proposed headlight system, the method enables a figure of merit to be calculated, which represents the degree to which glare would be reduced if the headlight system in question were generally adopted. It is necessary to make this assumption, since the resultant effect of glare depends both on the driver's own headlights and the headlights of the "other fellow." As examples, the figures of merit are worked out for three special beam distributions, one selected from each of the following general types: simple headlight employing no anti-dazzle device; dipped and swivelled headlight; headlight giving a flat-topped beam.

In practice, the beam distributions given by the headlights of different cars may exhibit wide variations owing to a variety of causes, even though the headlight equipment of the cars is nominally the same. It is necessary to take such variations into account when calculating the figure of merit of a headlight system. The report shows how this may be done and how due weight may be given to other disturbing factors, such as oscillations of the car owing to bumpy road surfaces.

* Illumination Research Technical Paper. H.M. Stationery Office. Price 1s. 6d. net.

Rail and Road.

THE agreement as to the new conciliation scheme for the railways was signed by representatives of the railway companies and of the railway trades unions on February 26th, and came into force on March 1st.

THE retirement is announced of Mr. W. A. Agnew, the Chief Mechanical Engineer (Railways) of the London Passenger Transport Board, who joined the Metropolitan District Railway in 1904. He has been succeeded by Mr. W. S. Graff-Baker. Mr. Agnew was one of the passengers in the Midland express concerned in the Hawes Junction disaster of December 24th, 1910, and gave evidence before Sir John Pringle as to the fire that followed the collision and the need for rescue appliances.

THE Member of Parliament for South Leeds from 1922 to 1931 was Mr. H. C. Charleton, who, at the time of his election, had been a driver on the Midland Railway for fifteen years, and, on the grouping of the companies, became a driver on the L.M.S. system, from which position he retired at the end of February after nearly fifty years' railway service. Mr. Charleton was a Junior Lord of the Treasury in the last Labour Government. He is an alderman of the London County Council, a justice of the peace, a governor of Queen Mary's Hospital, Roehampton, and—an interesting fact—a member of the Council of the Royal College of Music.

SPEAKING as to railway air services at the Great Western meeting on February 27th, the chairman, Sir Robert Horne, said that plans for further extension of that mode of travel were under consideration, and although some time must elapse before the air section of their business became a paying proposition, they were planning well ahead so as to ensure that they would obtain a full share of this form of transport. The London and North-Eastern has as yet taken no active steps in that direction. After referring to the formation of Railway Air Services, Ltd., the company's annual report observes that the development of air transport was being carefully watched, but no decision had yet been reached as to the operation of an air service on behalf of the L.N.E.R.

THERE have been three accidents to passenger trains within the last fortnight, all on the L.M.S. system. On February 21st, a train from Wirksworth to Derby ran into a landslide on the Wirksworth single-line branch at Duffield and the driver was killed. On the following Monday, February 25th, a passenger train from Birmingham to Ashchurch was derailed at Evesham, and the driver killed. Then, on Tuesday, the 26th, the 6.35 p.m. express from Liverpool Exchange, to Manchester, ran into a coal train which was crossing from the down main line, across the up main, to go to Aintree, at Fazakerley East Junction. The Evesham accident was being inquired into, on behalf of the Ministry of Transport, by Colonel Mount on Wednesday last, and the Duffield case was being investigated by Colonel Trench, yesterday—Thursday.

THE second of the reports of the main line companies to be published was the Great Western. It shows that the receipts from railway working for the year 1934 were £25,289,629, and the expenditure £20,350,475, as compared with £24,572,250 and £20,102,245 respectively in 1933. The number of passengers increased from 108,552,728, at an average fare of 1s. 3·29d., to 110,813,041, at an average fare of 1s. 3·18d. First-class passengers advanced in number from 887,953 to 904,146, and workmen from 24,686,776 to 26,714,202. The tonnage of freight traffic rose from 61,527,323 tons at an average of 4s. 5·36d. per ton, to 64,619,892 tons, at an average of 4s. 5·11d. per ton. The total engine mileage was increased from 39,527,651 to 40,685,597 for passenger traffic, and from 21,898,017 to 22,707,235 for freight traffic. The ratio of expenditure to receipts fell from 81·81 to 80·47.

ROAD transportation competition with the railways in South Africa takes one form to which we are not accustomed in this country. The South African Railways and Harbours report for the year ended March 31st, 1934, writing on the subject of road transport, says that the most unsatisfactory feature of the existing position is that competition from taxi operators in country districts continues unabated. These taxis do not operate to a schedule, with the result that the provisions of the Motor Carrier Transportation Act, governing their operations, become ineffective, and competition from that source remains unchecked and entirely beyond control. Many of the vehicles, especially those operated by non-Europeans, are not insured against third-party risk, notwithstanding which, and the attendant danger to passengers, they are eagerly sought after, and it is frequently reported that operators are convicted for overcrowding their vehicles. It is felt that the time has arrived when serious consideration should be given to the question of compulsory insurance of all vehicles operating for reward against third-party risk and damage to goods and for the more effective control of taxis.

THE forty-fifth anniversary, on March 4th, of the opening of the Forth Bridge recalls some remarks made in the half-yearly report of the North British Railway company in August, 1864. Apparently, some works had been contemplated at Queensferry and Inverkeithing in connection with a ferry across the Forth, and it was stated that the work had been in abeyance until it should be decided whether the Firth should not be crossed by a bridge. It was remarked that if the construction of a viaduct across the Forth could be accomplished at anything like the cost of the piers and other works required for the ferry, it was unquestionable that the latter should be abandoned and the bridge erected. That view prevailed, and in 1865, by 28 and 29 Vic. c 213, the bridge was sanctioned. Those powers lapsed, but were revived in 1873 by 36 and 37 Vic. c 237. The scheme lacked public support, and the little it had almost disappeared when the first Tay Bridge failed on December 28th, 1879. In 1882 the East Coast railway companies, with a strong backing from the Midland—whose chairman became chairman of the Forth Bridge Company—proceeded with the work, and the bridge was finished at a cost of £3,500,000. It is still an independent concern, with a board of six L.N.E.R. directors and of two L.M.S.

Miscellanea.

H.R.H. THE DUKE OF YORK has graciously consented to attend the annual dinner of the Institution of Naval Architects, which will be held on Wednesday, April 10th, at the Connaught Rooms.

THE Council of the Society of Chemical Industry has elected Mr. W. A. S. Calder, delegate director of the general chemicals group of Imperial Chemical Industries, as President of the Society for the year 1935–36. He will take office at the annual meeting of the Society in Glasgow from July 1st to 6th.

SIR JOHN SIDDELEY has been re-elected President of the Engineering and Allied Employers' National Federation. Commander Sir Charles Craven and Mr. G. E. Bailey have been re-elected Vice-Presidents and Sir William Ellis has been re-elected Chairman of the Finance Committee. Lord Weir of Eastwood has been added to the list of Trustees of the Federation.

TWO natural-gas engines have recently been supplied by the National Gas and Oil Engine Company, Ltd., of Ashton-under-Lyne, and installed on the shores of Lake Maracaibo, Venezuela, for the Anglo-Saxon Petroleum Company. They are each of 182 h.p., and drive 28in. Drysdale centrifugal pumps. The duty of these pumps is to combat the accumulation of surface water and pump it into the lake. The local rainfall may amount to as much as 6½in. in six hours.

THE Dominion Water Power and Hydrometric Bureau of the Department of the Interior of Canada, in its annual review of the country's water power resources, states that the total water power resources of the Dominion are now estimated at 20,347,400 h.p., under conditions of ordinary minimum flow, and at 33,617,200 h.p. ordinarily available during six months of the year. The present installation is 7,547,035 h.p., or less than 17½ per cent. of the possible commercial development.

THE General Secretary of the Society of Chemical Industry, Mr. H. J. Pooley, who was the first student to go through a course of chemical engineering at a British University—Liverpool, 1894–98—has been awarded the Osborne Reynolds medal for meritorious contribution to the progress of the Institution of Chemical Engineers. The medal, which was first awarded in 1928, is in honour of Professor Osborne Reynolds (1842–1912), the famous engineer whose researches on heat transmission and the flow of liquids are extremely important to the chemical engineer. Previous recipients of the medal include Sir Alexander Gibb, Sir Frederic Lewis Nathan, Sir Arthur Duckham, Professor J. W. Hinchley, J. Arthur Reavell, H. Talbot, S. G. M. Ure, and H. W. Cremer.

AN extract in the *Iron and Coal Trades Review* discusses the conditions in the Russian foundries, and points out that although the most modern plant has been provided, the quality of the castings is very bad and machines require constant repairs. The author maintains that this is due to the absence of foundry experience and a serious lack of knowledge in the handling of machinery generally. Sufficient spare parts are lacking, machines are not properly oiled, and repairs are not carried out in a proper way. The materials used are also not of the most suitable quality. The organisation of the whole foundry industry is lax, and, although improvements have become long overdue, no progress has been made. Certain foundries are idle owing to the shortage of suitable raw materials.

AN explosion, recently reported on officially, of a feed water heater at a power station in the Midlands, emphasises the necessity for safety or relief valves to be fitted immediately on the vessel they are intended to protect. This explosion resulted in the death of one man and the serious injury of several others. As originally installed the feed heater was supplied with low-pressure steam through a pipe in which there were a relief valve and then a stop valve. Subsequently, some other connections were made which might provide high-pressure steam directly to the heater. For operative purposes the stop valve was closed, which cut off the relief valve from the heater, pressure accumulated from the high-pressure drains, and the casing exploded. Had the relief valve been fitted directly on the casing of the heater, the explosion would probably not have occurred.

A SIMPLE method of transferring the spacing of twenty-four blind stud holes in an existing cylinder to a new cylinder head, described by Mr. H. Moore in *Power*, would appear to have possibilities in other classes of work. He first cut twenty-four pieces of cardboard, and punched a hole in each piece the same size as the tapped holes in the cylinder. One of these pieces was registered over each hole and glued to the cylinder. Next, glue was spread over the face of each cardboard piece. The new blank cylinder head was then carefully put into place. When the glue was dry on the cylinder head, the cardboard strips released themselves from the side of the cylinder. Thus, when the cylinder head was lifted, the pieces of cardboard were stuck to it with the holes in the exact position of the tapped holes in the cylinder. A centre punch mark in the centre of these holes made the head ready for drilling, the cardboard being left in place as a guide to the drill.

THE Tees is being made a first-class port, and according to a statement made at this week's meeting of the Commissioners, "it is ready for any call that might be made upon it." During the past four or five years the Commissioners have been engaged on a comprehensive scheme of river deepening and widening—improvements which are necessary to the growth of new industries and the larger ships sailing the seas. The work has been carried out in stages from the mouth of the river, and the last lap has been entered upon from the Transporter Bridge, Middlesbrough, to Stockton. These developments were estimated to cost half a million sterling. Simultaneously, the work of reclaiming a large area of Seal Sands on the Durham side of the river has proceeded apace. This development is being carried out at low cost. Material dredged from the river, slag, and other refuse from the works, which would have been dumped at sea in the ordinary course, is being pumped out of barges on to the Seal Sands by means of a special pumping station. The reclaimed land is to be offered for industrial sites.

Air and Water.

THE Worcester City Council has completed the purchase of an area of land of 92 acres at Perdiswell for the development of a municipal aerodrome.

SINCE 1931 the weight of freight carried by the Canadian Airways increased from 382 tons to 2883 tons in 1934. Last year 16,594 passengers were carried.

FOR the purpose of demonstrating the possibilities of a transcontinental air mail in India, a direct flight was recently made from Bombay to Calcutta in twelve hours.

SOME months ago an automatic recording balloon was sent up from Moscow, and reports say that it has recently been found with its instruments registering a height of 19 miles.

THE shipping losses for January, according to the casualty returns of the Liverpool Underwriters' Association, show the total loss of one motor vessel of 2900 tons gross and ten steamships of 27,233 tons gross. The partial losses numbered 562 vessels.

AS agreed between the Hamburg America Line and the North German Lloyd, the first German steamship service to the Far East will be maintained exclusively by the latter firm. The first voyage on the new route will by started on May 8th by the "Scharnhorst."

ARRANGEMENTS have been practically completed between the Doncaster Corporation and an aviation company for running daily air passenger and freight services connecting the town with London, Leicester, Norwich, Newcastle, Birmingham, and Bristol.

AN announcement has been made in Italy stating that the navigation bounty, which has been paid to Italian shipowners since 1932, will be continued during 1935. In the payment of the bounty, consideration is given to the age of the vessels, new ships receiving more than old.

ACCORDING to a note in *Machinery*, an aeroplane of Soviet construction, equipped with a Soviet-made engine took off recently from Moscow aerodrome with three pilots aboard and remained in the air for seventy-five hours, covering in that time a distance of approximately 8000 miles without refuelling.

DURING 1934, 5342 ships of 28,970,590 tons (Panama Canal net tonnage), carrying 25,900,152 tons of cargo and paying £4,871,664 at par in tolls, passed through the Panama Canal. This compares with 4612 vessels of 25,234,219 tons, carrying 21,146,760 tons of cargo, and paying £4,280,651 in the preceding twelve months.

DURING 1934 the net register tonnage of vessels cleared from the port of Belfast totalled 3,933,394 tons, some 273,279 tons more than the previous year. New tonnage constructed in the shipbuilding yards on the harbour estate and cleared during the year comprised eight vessels of 65,001 tons gross and 38,851 tons net register.

THERE are now two air mails each week from England to Iraq and India and to Central and South Africa. In addition, there is a weekly service between England and Burma, Malaya, the Netherlands East Indies, and Australia. The service to Egypt and Palestine now operates no fewer than four times weekly, and in this, as in every case, there is a corresponding return service to England.

TRIALS have been carried out on a new type of small high-speed armoured motor boat to combat smuggling and piracy in Chinese waters. She has been built by the British Power Boat Company, and is 45ft. long, drawing 2ft. 4in. of water, and weighs some 6 tons. She will carry four Lewis guns, and 1½ tons of fuel, and be driven by three 100 h.p. engines. Her cruising range will be about 420 miles.

IN reply to a question in the House of Commons, Sir P. Cunliffe-Lister said he had recently approved a proposal by the High Commissioner for Palestine to spend a sum of £10,000 on the preparation of detailed plans for the further development of Haifa Harbour, including additional quay berths and storage accommodation, in order that such plans might be in readiness for execution as demand required. The question of construction of additional facilities would be considered when the plans were available. A description of the present harbour at Haifa appeared in THE ENGINEER of November 3rd, 1933.

THE new passenger, cargo, and livestock-carrying steamer, "Duke of York," now under construction by Harland and Wolff, Ltd., Belfast, for the L.M.S. Railway's Heysham-Belfast service, was launched yesterday (March 7th), when the naming ceremony was performed by the Duchess of Abercorn. The principal dimensions of the ship are: Overall length, 349ft.; breadth (moulded), 52ft.; depth (moulded), 19ft. 6in.; speed, 21 knots. The "Duke of York" will be equipped with mechanical stokers, and with an automatic sprinkler and fire alarm system throughout the passenger accommodation.

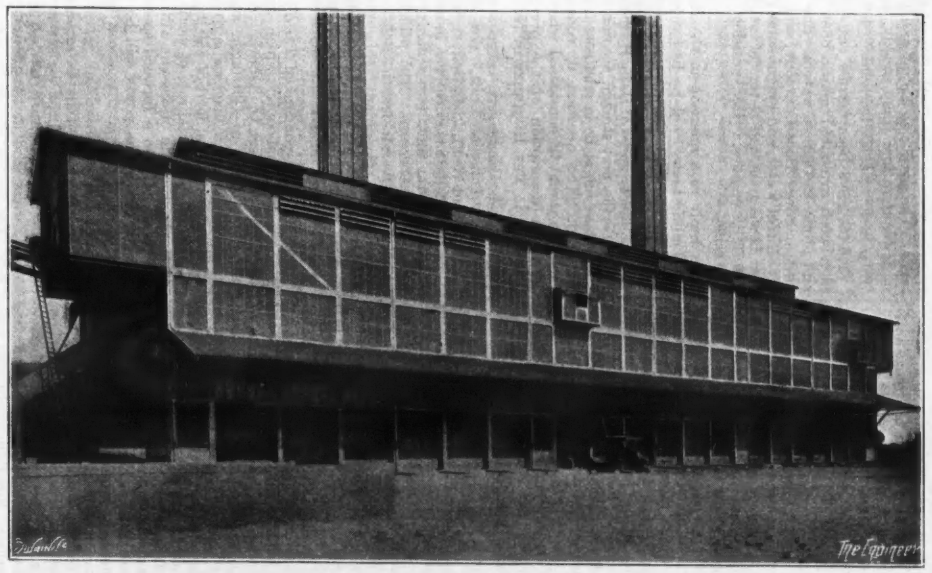
THE air correspondent of *The Times* recently described a commercial helicopter which has been invented and developed by Herr O. Asboth. A series of experiments have been made at Göttingen and Aachen, and, based upon these tests, a machine is to be constructed capable of carrying a useful load of 880 lb., having a total weight of 3680 lb. Its initial rate of vertical climb will be 1500ft. a minute, the rate of descent will be not more than 15ft. a second. Up to a forward speed of 22 miles an hour, part of the engine power will be required for operating the rotors, and over that speed lift will be obtained by auto-rotation.

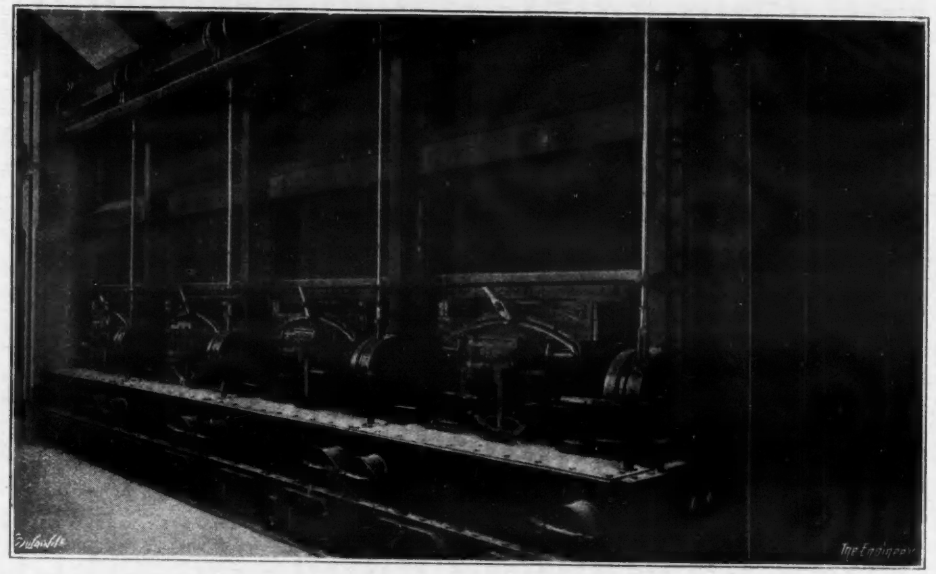
IT is announced that an arrangement has been made for the doubling of the air service between London and Switzerland from April 1st. A Swiss Air machine will leave Switzerland in the morning and return to Zurich from London in the afternoon. Tickets will be interchangeable between the Swiss Air service and Imperial Airways, which has for some years operated a service to Zurich by way of Paris and Bâle, an aeroplane leaving London in the morning and returning in the afternoon. For the first time a stop will be made at Lille for the convenience of business men. The journey between London and Zurich is scheduled at 3½ hours. The joint service will be in operation until October 5th.

THE BORDEAUX REFUSE DESTRUCTOR PLANT

HEENAN AND FROUDE LTD., WORCESTER, ENGINEERS

(*For description see page 244.*)





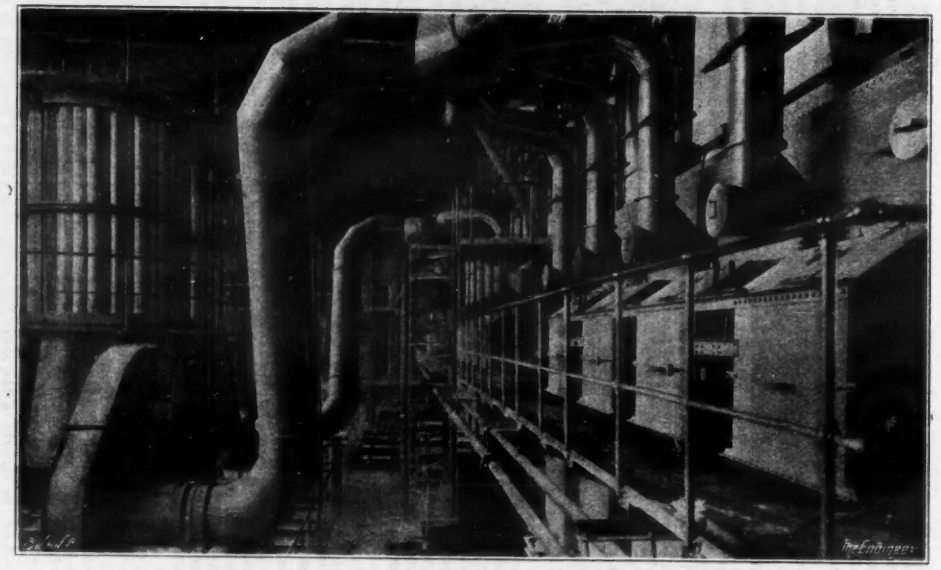


FIG. 5 (ABOVE):—EXTERNAL VIEW OF REFUSE DESTRUCTOR PLANT
FIG. 6 (BELOW):—BATTERY OF FOUR DESTRUCTOR FURNACES

FIG. 7 (ABOVE):—GENERAL VIEW IN BOILER ROOM
FIG. 8 (BELOW):—GENERAL VIEW OF DUST SUCTION PLANT

The Engineer

MARCH 8, 1935.

VOL. CLIX. No. 4130

Contents.

THE ENGINEER, March 8th, 1935. PAGE

A SEVEN-DAY JOURNAL ... 241
THE DEVELOPMENT OF PARSONS INDUSTRIAL TURBO MACHINERY. No. IX. (Illus.) ... 242
THE BORDEAUX REFUSE DESTRUCTOR PLANT. (Illus.) ... 244
LEIPZIG TECHNICAL FAIR. No. I. (Illus.) ... 247
THE ENGINEERS' GERMAN CIRCLE ... 248
INSPECTION OF ENGINE COMPONENTS BY THE "MAGNA-FLUX" METHOD. (Illus.) ... 249
THE DESIGN OF SAFE LOAD INDICATORS ... 249
SIXTY YEARS AGO ... 250
THE EVALUATION OF GLARE FROM MOTOR CAR HEADLIGHTS ... 250
SOUTH AFRICAN ENGINEERING NOTES ... 250
ROAD AND RAIL ... 251
MISCELLANEA ... 251
AIR AND WATER ... 251
LEADING ARTICLES—
Standardised Worm Gears ... 253
Private Electric Plant *v.* Public Supply ... 253
A REFLECTION METER AND ITS APPLICATION. No. II. (Illus.) 254
BOOKS RECEIVED ... 255
WORM GEAR PERFORMANCE. (Illus.) ... 256
HOLLOW SHAFT PUMP MOTORS. (Illus.) ... 258
A FAST DROP HAMMER. (Illus.) ... 258
A CRANE SAFE LOAD INDICATOR. (Illus.) ... 259
HYPOSYNCHRONOUS MOTOR ROLLING MILL DRIVE. (Illus.) ... 259
A NEW MAGNETIC CLUTCH. (Illus.) ... 260
SYNCHRONOUS TIME MOTORS ... 260
BOOKS OF REFERENCE ... 260
PERSONAL AND BUSINESS ANNOUNCEMENTS ... 260
CONTRACTS AND ORDERS ... 260
CATALOGUES ... 260
MARKETS, NOTES AND NEWS ... 261
CURRENT PRICES FOR METALS AND FUELS ... 262
FRENCH ENGINEERING NOTES ... 263
BRITISH PATENT SPECIFICATIONS. (Illus.) ... 263
FORTHCOMING ENGAGEMENTS ... 264

NOTICES TO READERS.

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*** *No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.*

NEW POEM BY MR. RUDYARD KIPLING.

With our issue of March 15th we shall present as a one-page supplement a hitherto unpublished poem entitled "Hymn of Breaking Strain" by Mr. Rudyard Kipling. It is desirable that non-subscribers should place orders for copies of this issue immediately.

STANDARDISED WORM GEARS.

IT can hardly be said that the long discussion which followed Dr. Merritt's paper at the Institution of Mechanical Engineers on February 22nd added much to the information given by the author. A good part of it turned upon the means of testing, and but little upon the form of worm which the British Standards Institution is about to standardise by the publication of a specification. One or two speakers, however, did point out that there were other forms which gave equal efficiency, and the ease of manufacture of the approved design was the subject of questions to which the author had not time to give an oral reply. We must presume that the B.S.I. has satisfied itself and manufacturers that the involute helicoid—as it is called—is a contour which can be reproduced readily and economically, and gives better endurance than any of the competitive forms. In view of the very high efficiencies which are obtainable with many worm forms—efficiencies in the neighbourhood of 98 per cent. on test—the margin for further improvement in this quality is extremely small, and may be practically neglected in comparisons. The problem, therefore, appears to be, as we have suggested, the selection and standardisation of a contour which offers facilities for manufacture and can be counted upon to show good efficiency in service over a prolonged period.

In the discussion one speaker asked to be assured that a real need for standardisation of worm gearing existed, and in his reply Dr. Merritt said that that was the most important question put to him. He did not challenge the speaker's statement that the production of worms and wheels was a highly specialised industry which was passing into the hands of a very few firms in this country. It is, we think, manifest that on that ground standardisation might be opposed. Furthermore, we suggest that interchangeability is never likely to be an important factor in worm gear production. Hence, two of the leading arguments for standardisation are not valid in this case. Dr. Merritt did not present them. The burden of the argument which he advanced is that even at this day consulting engineers are prone to draw up their own specifications for worm gear, and that the publication of a standard specification would check the continuance of that practice. With due respect to the British Standards Institution we must say that we do not find this argument very effective in this case, sound as it is for rolled steel sections and similar products which demand the existence of expensive equipment. It is very difficult to see that any great benefit will ensue from the few existing makers of worm gearing all making to a standardised form. *Per contra*, there is just a chance that standardisation of their product may exhibit one of the dangers which inevitably accompanies it—the danger that other designs may not be explored. The involute helicoid worm would, we take it, always be obtainable from Dr. Merritt's firm, which originated it. Would, we ask, any great harm be done, and might not good result, if other firms continued to produce the forms with which they have secured satisfactory results for years past? The outcome of the standardisation, if it attains the goal at which, according to Dr. Merritt, it is aimed, must be that only on rare occasions will other forms than that specified be ordered. It may be that the B.S.I. has satisfied itself that the summit of perfection has been reached in the involute helicoid, and that it is vain and fruitless to produce other contours. It is, however, more probable that the B.S.I. will assert that, as with all specifications, progress cannot be arrested, for it is always ready to adopt modifications of specification made necessary by the advance of knowledge. Again, in this case, the argument is not very effective, for it is unlikely that anyone will readily overcome the difficulty of obtaining other designs in order to seek for improvements. In fact, the object of the specification, once more following Dr. Merritt's reply, is to check enterprise of that order.

It may be that when the specification appears it will succeed in making clear, in a Foreword, the necessity of standardising worm gear, but we should be neglecting our duty if we failed to notice that so far it is but one more example of those which many engineers hold to be unnecessary. Our own sympathies with reasonable standardisation are well known, yet we cannot be blind to the fact that there are many who contend that it is being carried too far, and that more limitation than is desirable is being placed upon the inventiveness of designers and manufacturers. We are not within the secrets of the Council of the Institution of Mechanical Engineers, but could not fail to notice that in its Annual Report, presented at the last meeting, it had recommended a substantial reduction of its annual grant to the B.S.I. In doing that is it not possible that the Council, pursuing its proper duty, is reflecting a feeling of some degree of dissatisfaction amongst its members? We must, for the moment, leave the matter at this stage, but when we consider the frequency with which criticism of this order of the B.S.I. is heard, we suggest that before long it will have, for its own peace of mind, to subject its policy to a general inquiry, either for approval or modification.

Private Electric Plant *v.* Public Supply.

ON those rare occasions when papers which should produce good discussions are read before engineering institutions, the results do not always come up to expectations. Whether those who are in a position to discuss specified subjects miss the announcements of forthcoming meetings, or whether they deem it best not to oppose views they do not share, is difficult to say; but the fact remains that when an author happens to advocate a policy which cannot possibly meet with universal approval, the criticism he experiences is often mild. If there is a subject which, at the moment, should readily lend itself to discussion, it surely is that of the relative cost of generating electricity privately and purchasing it from outside. While private plant manufacturers naturally support the former policy, those behind the grid are apparently always ready to prove on paper that, when all things are taken into account, purchased current is cheapest. When manufacturers had no alternative to the practice of generating their own current, they were simply faced with the problem of selecting a suitable prime mover. Public supplies at reasonable prices were at one time only available in relatively few places, but under prevailing conditions factory owners and others are constantly finding it essential to examine the claims of those whose business it is to sell current.

The paper on "Private Plants and Public Supply Tariffs," read by Mr. J. A. Sumner before the Institution of Electrical Engineers on Thursday, February 28th, is therefore a timely contribution. It gives engineers belonging to the two parties striving to secure business an opportunity of stating their cases, and of clearing up misunderstanding. But, although Mr. Sumner's conclusions are far from satisfactory from the point of view of oil engine manufacturers, the London discussion was devoid of real defence. What sort of reception the paper will receive in other parts of the country in which more important industrial power users are to be found remains to be seen. True, one speaker complained that the author had been unfair to the pass-out turbine, while another, known to have little sympathy with the grid, pointed out, among other things, that the paper only covered plants up to 500 kilowatt. Opposition from oil engine manufacturers was, however, entirely lacking, notwithstanding the author's statement that in no case within his knowledge is current produced by these engines at the well-advertised price of ½d. per unit. Briefly, the author's conclusions, based on investigations in a semi-rural area, are that an efficient public supply undertaking can provide untransformed H.T. power at a lower cost than that at which the power can be generated by any modern form of prime mover installed on the consumer's premises, although an exception may arise if a factory requires steam primarily for process work, and secondarily for power production. The averaged public supply tariff which will enable H.T. power to be obtained as economically as it could be generated by means of a large oil engine, is estimated to be £4·95 per kilowatt of maximum demand for an average of thirty minutes, and 0·4d. per unit, rising to £6·6 per kilowatt of maximum demand, plus 0·53d. per unit in the case of smaller plant. The cost of power generated by small residential plants is also shown to exceed that at which it can be obtained from an efficient and modern public supply undertaking. The author's assertion that it is probably correct to say that the majority of private plant owners have no real knowledge of the cost per kilowatt-hour of power production from their plant may not be far from correct. On the other hand, there are, of course, industrial establishments in which all the factors which go towards making up the total cost of current are thoroughly understood, and in which private plant continues to operate because it can show advantages over the public supply. The author's investigations are said to represent the results of inquiries made over a period of two years for approximately thirty private industrial plants installed in engineering and industrial works and small collieries. Some of the plants were installed twenty years ago, while others were put into service as recently as 1931. In only twelve cases were fairly accurate costs available, and these were chosen as representative of the type of plant in the particular semi-rural area of supply. Steam, gas, and heavy oil engine installations were apparently included. The main item in determining the cost per unit of power produced per year, which is the basis of comparison adopted in the paper, is shown to be the annual load factor at which the plant can run. For small works running forty-eight hours per week, the load factor is very low, and the annual standing charges on the high initial cost per kilowatt of oil engine plant are found to be at the root of the high price per unit produced. While it is admitted that when a works is running continuously the oil engine shows better results, it is argued that a cessation of output from the factory is more serious and the time available for plant maintenance is much less. For this reason it is concluded that more spare plant must be installed than is required for a works running intermittently, and the advantage derived from running a greater number of hours during the year may be neutralised.

The author is less happy, however, when he

comes to consider electricity supply tariffs, which, as is well known, differ widely throughout the country. It can hardly be disputed, he says, that one of the most serious hindrances to the proper development of public supply is the extraordinary inequality of the charges made for current in different, but contiguous, electricity areas. Provided some co-operation were obtainable between undertakings, it is considered to be financially possible to achieve an approach to one tariff common to all undertakings throughout the country to enable each consumer to pay on the same basis; but whether such a happy state of affairs will ever be realised is doubtful. If feeling on the matter can be judged from the discussion, the essential co-operation will not be easily attained. The diversity of tariffs is undoubtedly a decided obstacle to the development of public electricity supplies, but another item which is very apt to tempt manufacturers to generate current is the frequency with which supplies now fail. Since the advent of the grid the unreliability of purchased electricity has been demonstrated in a way hitherto unknown to most British consumers, and it is not to be wondered at that manufacturers of small and medium-sized generating units are not yet contemplating putting up the shutters and drawing the blinds.

A Reflection Meter and its Application.

By W. P. DIGBY.

No. II.

(Concluded from page 221, March 1st.)

POLISHED tin and polished silver are not the only media whereby the effect of corrosive atmospheres may be compared, or the effect of the same atmosphere on different alloys studied by photometric means.

Dr. Hatfield, of the Brown-Firth laboratories, very kindly sent the writer five sets of steel plates identified by him by numbers. The understanding was that two of these should be nickel-chrome-iron alloys respectively high and low in nickel content, one ordinary carbon steel, one nickel steel without chromium, and one a manganese steel. These were given a mirror polish and placed with a silver-copper eutectic plate on a window sill in Westminster. Daily readings were taken from 9.30 a.m. on August 28th, to 9.30 a.m. on September 4th—192 hours.

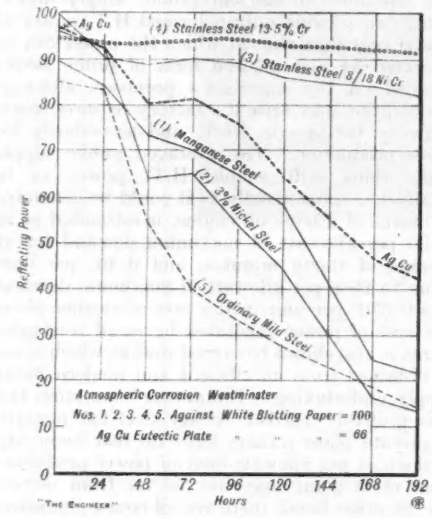

Ag Cu
(4) Stainless Steel 13·5% Cr
(3) Stainless Steel 8/18 Ni Cr
(1) Manganese Steel
(2) 3% Nickel Steel
Ag Cu
(5) Ordinary Mild Steel
Atmospheric Corrosion Westminster
Nos. 1. 2. 3. 4. 5. Against White Blotting Paper = 100
Ag Cu Eutectic Plate " " " = 66
Reflecting Power
Hours
"The Engineer"

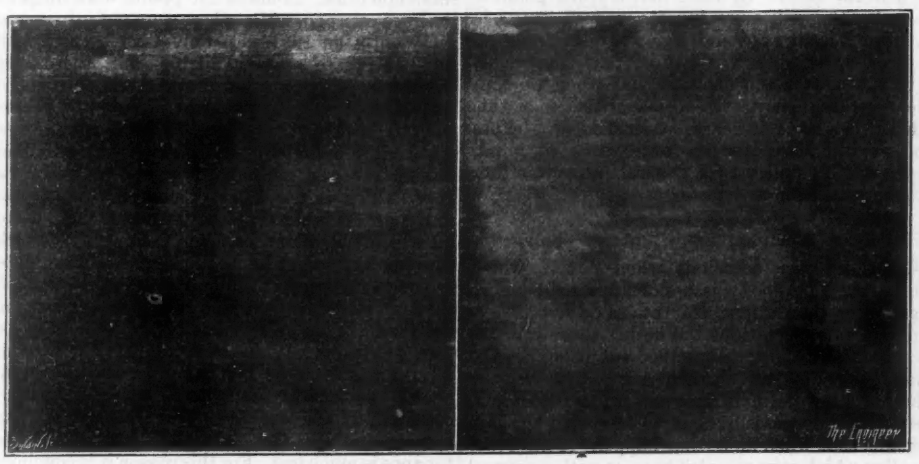
FIG. 6—REFLECTING POWER OF STEEL PLATES

The results are set out below and also in Fig. 6.

Flue Gas Tests.

Two "silver-copper eutectic" plates were placed in the flue of a coke fire of the foundry store at some large engineering works.

One plate was exposed for 1¼ hours—Fig. 7—and one plate for 2½ hours—Fig. 8.



FIGS. 7 AND 8—SILVER-COPPER EUTECTIC PLATES—FLUE GAS TESTS

On the first plate the discolouration was very vivid—blue, pink, and green colouration—colours were not in segregated patches, but shading from one to the other in definite areas of an iridescent character. Discolouration was most marked where the bottom edge of the plate rested on the bottom of the flue. That is to say, that the colour was dark brown without iridescence, and the film almost thick enough to be classed as a patina.

The reflection varied somewhat on the first plate; there was evidence of gas eddies, values being 47 per cent. on one side and 69 per cent. on the other.

The second plate, which was given a two hours' exposure, was more deeply patinated, and while there was evidence of eddies, the iridescent area was comparatively small. The reflection measured on each side was only 37·5 per cent.

As the temperature of the gases in the flues at the time that these exposures were made was 300 deg. Fah., it is evident that the tarnishing, while it may be intensified by an excess of moisture at low temperature, is independent of water at a higher temperature.

So much for the effects of atmospheres and of flue gases, supposedly normal, on silver and on polished samples of steel. The results between one day and another day at the same place and between different places on the same day do not show greater variations than those which the reports of the Department of Scientific and Industrial Research have led us to regard as normal for the sulphur dioxide content of the air in large towns.

It was also anticipated that the tarnishing produced in corrosive solutions would also show marked variations. To establish this five samples of steel were courteously furnished, as before, by Dr. Hatfield, of the Brown-Firth research laboratory. These were merely numbered 1–5, no indication was given which would enable anyone to classify them, and no chemical analyses were made of their composition. The plates were polished and then placed for seventy minutes in water from No. 1 spring at Strathpeffer. The typical analysis of this water gives 2 grains of sulphuretted hydrogen, 18·89 grains of sulphate of lime per gallon.

A further test to show the progressive change was taken in water from No. 4 spring at Strathpeffer. The measurements were made at intervals of fifteen and thirty minutes. An analysis from this spring gives 6·6 grains of sulphuretted hydrogen, 50·92 grains of sulphate of lime, and 31·08 grains of sulphate of magnesia per gallon.

In both cases it is evident that the exposures were too long, and it would have been better to have diluted some of the mineral water from the springs with distilled water. The results do, however, definitely enable one to grade the metals in their order of resistibility to corrosion. It appeared that sample No. 4 would probably be of a nickel chromium steel with high nickel content, and No. 3 of a nickel-chromium steel of lower nickel content. This was actually the case.

Of the three remaining samples, No. 1 (the manganese steel) was slightly superior to No. 5 (ordinary mild steel), and No. 2 (a 3 per cent. nickel steel).

Exposures on Office Window Sill, Eight Days from August 27th, 1934.

Steel plates		1	2	3	4	5	Ag Cu eutectic
Initial reflecting values		89	95·5	99	94	85	96
August 28th, Tuesday	24 hours	84	92	90	91·2	83	92
August 29th, Wednesday	48 hours	73	64	89	93	55 (rust)	80
August 30th, Thursday	72 hours	70	65	90	94	40	80
August 31st, Friday	96 hours	64·7	53	89	94	33	76
September 1st, Saturday	120 hours	58	44	86	93	28	64
September 3rd, Monday	168 hours	25	16·2	84·2	88 ?	12·3 ?	55·2
September 4th, Tuesday	192 hours	22	13·5	82	91½	15	51·5

NOTE.—For Nos. 1 to 5, white blotting paper = 100; for C23, white blotting paper = 66.

Ferrous Alloy Plates Immersed in Water from Strathpeffer Spa, Spring No. 1. Period of Immersion Seventy Minutes. *(See also page 255.)*

	Initial values (white blotting paper equalling 100).	As measured after seventy minutes with adherent film.	As measured after washing off film and drying.	Final appearance.
	Per cent.	Per cent.	Per cent.	
Plate No. 1	89	29·5	74	Film was a pale brownish blue colour; the plate was pitted over most of the area
Plate No. 2	95·3	10	64·8	Film dark brown blue and purple colour, not adherent. After cleaning the surface of plate was yellow
Plate No. 3	87	82·5	87·8	A few rust marks on one edge
Plate No. 4	90·7	89	91·3	No film at all
Plate No. 5	86·5	39	70·4	Pale buff film and pitting

Colour Changes in Paint.

There are numerous standard specifications dealing with the chemical composition of paints, but the clauses governing the physical properties of the marketed article are inexact. While it is specified, for instance, that the fading under ultra violet light shall be measured from a carbon arc carrying a certain current and placed at a definite distance from the painted article under observation, the change or fading due to ultra violet light is specified as being not less than that of the approved sample. Many

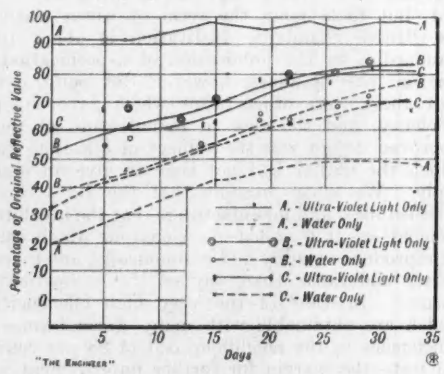


FIG. 9—COMPARISON OF THREE RED PAINTS

others, beside the writer, have found that the bleaching due to ultra violet light is not always permanent. In some cases there is a definite recovery of colour; in others, little or none. The recovery is a somewhat rapid one in the initial stages after short exposure, but after long exposure the recovery value would seem to disappear.

Certain paints also bleach on immersion in potable waters, both hard and soft, and here, again, the recovery of some paints is more permanent than that of others.

There are methods also of combining the effect of ultra violet light and water. These are of interest in regard to paints for decorative purposes. Many will perhaps have noticed that in the clean air of a mountainous district, many miles from any industrial centre, some paints applied to steel structures will, in the event of bright sunshine following upon a shower, show marks of the rain drops. These marks, however, disappear.

Description of Fading Test.

From the point of view of the user of the paint, it would be preferable to define more exactly the permissible colour change, whether due to light or water, and to express the margin, if any, between the standard reference sample and the paint being compared with it. It would also appear to be advisable to define the time elapsing between the completion of exposure and the making of the comparison between the samples, as some paints possess a much greater recuperation value than others.

Fig. 9 compares three red paints, two of which were exceedingly susceptible to light, and which were also found to be bleached by water. In each case, the initial reflection value of the paint itself was taken as 100. After eight hours' exposure to ultra violet light only, paint A had lost only 2 per cent. of its initial reflection value; paint B had lost 48 per cent.; and paint C, 40 per cent. In thirty-six days, paint A was unchanged, paint B had recovered 30 per cent. (making the net loss 18 per cent.), and paint C had recovered 22 per cent. (making the net loss 18 per cent.).

Exposed to the action of water only, paint A lost in eight hours 80 per cent. of its reflection value, and in thirty-six days, owing to recuperation, the net loss was 52 per cent. In the same time, paint B lost 62 per cent., and in thirty-six days the net loss was 28 per cent. Paint C lost 68 per cent., but had a better recovery value, the net loss being 32 per cent.

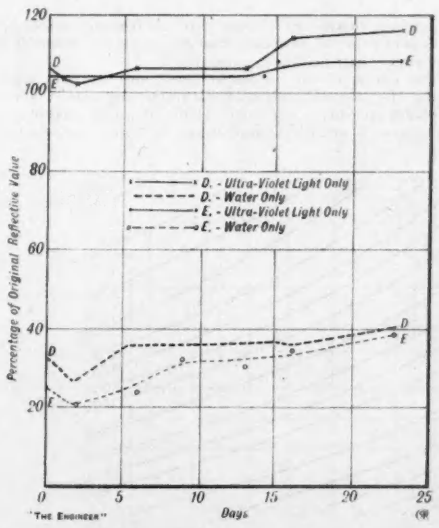


FIG. 10—COMPARISON OF TWO GREEN PAINTS

The action of ultra violet light alone is of a two-fold character—there is a lightening of colour and a loss of glossiness. The effects therefore are divergent. Where the loss of glossiness is inappreciable, there may be an actual increase in the reflecting value as the paint has become lighter. Where the loss of glossiness is large, the recuperation is due to the regaining of part of this glossiness.

In Fig. 10, which contrasts the behaviour of two different green paints after exposure respectively to ultra violet only and to water, we have for ultra violet light only an actual increase in reflecting power, a temporary loss of glossiness being insufficient to outweigh the bleaching effect. For water only the recuperation is not so large as in the earlier case, perhaps owing to the longer exposure period of fifty hours.

Paint D when measured after fifty hours' exposure to ultra violet light had a reflecting value of 106, or 6 per cent. over that of the paint before exposure; in twenty-three days this rose to 108. Paint E had a value of 104, which increased to 116.

In water, paint D, which had fallen to 32 per cent., rose to 40 per cent.; and paint E, which had fallen to 24, recovered to 38 per cent.

To summarise other laboratory tests which are still in progress, it would appear that:—

(i) Under ultra violet light only all pigments become lighter in colour, but painted plates initially indistinguishable fade at different rates, dependent presumably upon some difference in their base or in the nature of the pigment employed.

(ii) This fading is sometimes, but not always, accompanied by the loss of glossiness.

(iii) The fading is not permanent, but there is a recovery of some, but not all, of the loss of colour.

(iv) In water only all paints become lighter in colour, and painted plates initially indistinguishable fade at different rates, as in (i) above, and the greatest action takes place below the water line. Further, this fading takes place in the dark, as well as in daylight, but it has not yet been ascertained whether it is greater in daylight than in a dark cupboard.

(v) The fading in water only is always accompanied by a loss of glossiness.

(vi) The fading and loss of glossiness are not permanent, but there is a partial recovery, first of colour and then at a much slower rate of glossiness.

(vii) The combined effect of the bleaching and loss of glossiness are indicated by comparative readings on a photo-electric cell, as well as the total tendency to recovery. This combined effect is made up of two opposite phenomena. The reflection should be increased by the fact of the paint becoming light and decreased by the loss of glossiness.

From the above, the following tentative deductions may be made:—

(i) That all the paints tested to date are unstable; perhaps the effects noted would be less pronounced on paints which had been kept for three, six, or nine months after application to wood or metal before testing.

(ii) That this perhaps is not material from the commonsense point of view. One cannot paint a steel girder and put the girder in a cellar or cover it with a dust sheet, or keep a ship in dry dock for a month. Therefore, the fact that our tests have been taken on relatively newly applied paints does not appear to be material. (Scientifically regarded, there may be something to be said for clearing up this point; in countries with marked wet and dry seasons, it might be better to apply paint to any existing structure immediately at the end of the wet season instead of immediately before the wet season.)

(iii) That the instability may be due to the linseed (or kindred) oil in the lower layers being not completely oxidised and therefore flowing slowly back into the bleached de-glossed surface. This last speculation can be checked when the recovery is stabilised by repeating the alternatives of exposure and recovery until the recuperation ceases.

(iv) That while loss of glossiness reduces the reflection value of a painted surface, the bleaching would tend to increase this reflection value. These conversely divergent effects could possibly be neutralised, so far as the loss of gloss is concerned, by giving the affected area a very thin coat of a quick-drying varnish. We should then, owing to the bleaching of the pigment, have a higher reading on the reflection meter than before the paint was bleached.

Summary.

Varied and seemingly haphazard as these preliminary notes on the use of a reflection meter may appear, each citation given has had its direct bearing on other work, or other problems, with which the writer was concerned.

Thus, when the paint on one side of a building or steel structure weathers badly, and the paint lasts well on the other side, it is important to know whether the explanation is that the trouble is solely due to sun and rain and the prevailing wind, or whether atmospheric impurities are a contributory factor.

Ferrous Alloy Plates Immersed in Water from Strathpeffer Spa, Spring No. 4, Readings being Taken After Fifteen and Thirty Minutes.

	Initial values (white blotting paper equalling 100).	After fifteen minutes.	After thirty minutes.	Final appearance after drying.
	Per cent.	Per cent.	Per cent.	
Plate No. 1	92·2	24·8	27	Blue film, lower part rusted
Plate No. 2	99	21·5	8	Deep blue and purple film, slight rust
Plate No. 3	87	79·5	79	A few small blue spots
Plate No. 4	91·8	91	92	Clean
Plate No. 5	87·8	25·7	15	Deep blue and purple film, heavily rusted

Also, when it was noticed that the bleaching effect of ultra violet light is not always permanent, but that some paints showed recuperative properties to a greater degree than others, it was important to have a rapid means of estimating the extent of each of these changes.

Again, corrosion due to the constituents of gaseous and liquid media has been a matter of deep concern which no engineer escapes. Our methods of investigating the phenomena of the surface and molecular change which we call corrosion, are exceedingly diverse. For some metals and some substances the films formed are protective, for others they are not. Thus, we have the natural patination of a flint scraper or arrowhead, of a bronze spearhead or ornament. These effects are relatively permanent and preservative. So, also, is the patina on certain Chinese bronzes, the colour of which varies with their composition, with a colour change from black to claret.

Rust, of course, is anything but protective.

Finally, architects, antiquarians, property owners, and public health authorities are likely to become as exacting in their requirements of atmospheric purity as water authorities are in regard to contamination of water which is to be impounded for drinking. We are no longer content to blame only the domestic grate, or only the factory chimney for the emission of black smoke, although from time to time house owners, and, in some areas, factory owners, are subject to summonses by the local authority. Increasing attention is given to constituents also deleterious but less visible at the point of emission.

It is certain that the difference in the loss of reflecting power of silver or of a silver alloy, or other metals and other alloys in different areas, or in different air streams, such as boiler-house flues, indicates a difference in the concentration or composition of the corrosive media.

It may be worth while for others to correlate such simple indirect means of relative estimation of the amount of tarnishing with the direct measurements of a detailed chemical analysis.

Sources of error in measuring changes of reflecting power would appear to be mainly in the failure to remove all traces of the polishing medium after reaching a mirror-like polish; washing in methylated spirit and then rinsing in distilled water appears to be a sufficient safeguard in the case of polished silver alloys, or of polished steels. Other sources of error will be in the variation of the e.m.f. of the battery supplying current to the lamps of the reflection meter.

Dust, soot, and other deposited adherent matter have to be considered. The action even of soot containing sulphur may be less severe on a dry than on a damp day. The speed and direction of wind, the absence of such eddies as are found on window sills, or in close proximity to buildings, must all influence the results. Again, the moisture falling during the first few minutes of a drizzle, following upon a period of air stagnation, may be quite heavily loaded with corrosive material, or even clean water falling upon a dust-coated plate might cause an accelerated corrosion. On the other hand, heavy rain, say, of a thunder shower, would quickly wash away the dust deposited during several days. In short, correlation of the measurements of atmospheric impurities and the loss of reflecting power of any polished metallic surface appears to be an interesting field for study, whether we use tin or tin alloys, silver or silver alloys, or ferrous materials.

For tracing the distribution of sulphur from any given centre, or group of centres which must involve taking a large number of measurements over a wide area, the reflection meter and silver plate would meet most needs, and will permit of observation at high altitudes, provided, of course, that the Air Ministry approve, or that the members of the flying clubs would be willing to assist.

Finally, the writer has to acknowledge his indebtedness in an unusual degree to the assistance of a number of friends, many of whom have exposed plates for him under known conditions. Notably, Mr. J. W. Patterson and Mr. Ernest Nightingale, who have also assisted with advice as to the correlation of the physical phenomena of change in reflecting power with changes in the composition of the media effecting the change, and to Mr. Herbert Bell for the construction of many of the forms of apparatus used in the early stages, and for the patient compilation of results. Colonel Edgcumbe's assistance and advice has already been mentioned.

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The Motor Electrical Manual. Sixth edition. London: The Temple Press, Ltd., 5–15, Rosebery-avenue, E.C.1. Price 2s. 6d. net.

Stratosphere and Rocket Flight. By C. G. Philp. London: Sir Isaac Pitman and Sons, Ltd., Parker-street, W.C.2. Price 3s. 6d. net.

Annual Report of the Egyptian Ministry of Public Works. Part 2. Cairo: Publications Office, Government Press, Bulâq. Price P.T. 30.

Precision Workshop Methods. By H. J. Davies, M.Sc. London: Edward Arnold and Co., 41, Maddox-street, W.1. Price 20s. net.

Worm Gear Performance.*

By HENRY E. MERRITT, D.Sc. (Eng.), M.I. Mech. E.†

(*Concluded from page 236.*)

Worm Gear Tooth Loading.—On the foregoing basis, a method of determining allowable tooth loading for worm gears may be constructed.

Reverting to the involute worm, it follows from its properties that every normal to the tooth surface makes a constant angle with the axis, this angle being equal to the base lead angle. Hence, taking a length δs of line of contact under a load P lb. per inch, the component of the normal reaction in the direction of the axis will be $P \delta s \cos \lambda_o$. The pitch radius of the wheel being $T m/2$, the torque due to this length of line contact will be

$$P \delta s \cos \lambda_o \, T \, m/2 \, \eta.$$

Now the allowable load P depends upon the relative radius of curvature R_r, and if S_c denotes the stress factor for the materials,

$$P = \frac{\text{Allowable load}}{\text{Length of line of contact}} = S_c \, R_r^{0.8}$$

Hence the torque capacity due to the length δs will be

$$\frac{S_c \, \delta s \cos \lambda_o \, T \, m \, R_r^{0.8}}{2}$$

The total torque capacity due to the sum of the lengths of all the simultaneous lines of contact will be

$$M = \frac{S_c \cos \lambda_o \, T \, m \, \Sigma \, \delta s \, R_r^{0.8}}{2}$$

Taking R_r as constant and equal to $\frac{T \, m \sin \lambda_o}{2}$ we have

$$M = \frac{S_c \cos \lambda_o \, T^{1.8} \, m^{1.8} \sin \lambda_o^{0.8} \, s}{2 \times 2^{0.8}}$$

$$= \frac{S_c \, D^{1.8} \, s \cos \lambda_o \, (\sin \lambda_o)^{0.8}}{2^{1.8}}$$

In order to apply this formula to any given design, it is necessary to determine the zone and lines of contact in order to find the value of s. This has been done for a very

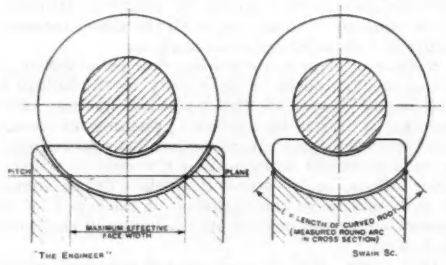


FIG. 10—*Effective Face Width of Wheel.*

FIG. 11—*Length of Curved Root.*

large number of designs of worm, ranging from one to ten starts, and a corresponding range of ratio of diameter to pitch. It is found that the product

$$\frac{s \cos \lambda_o \, (\sin \lambda_o)^{0.8}}{2^{1.8}}$$

is substantially constant in relation to the face width f_W of the wheel (provided that this is substantially equal to the maximum effected face width f_{eW} mentioned later), in the proportion

$$\frac{s \cos \lambda_o \, (\sin \lambda_o)^{0.8}}{2^{1.8}} = 0{\cdot}18 \, f_W$$

This relation slightly favours worms in the lower range of lead angle, but this is in the right direction in view of the whichever is the less (see Fig. 10). The reason for this is that at the position of shortest total length of line of contact the most effective portions of the contact lines are below or near the pitch plane.

Strength of Wheel Teeth.—It will be gathered from the attention bestowed in the foregoing upon surface loading, that actual breaking strength is a secondary consideration This is true of all types of gear, for the reason that torque capacity based on surface pressures is limited by the major dimensions, whereas strength is mainly dependent upon pitch, which can usually be selected at will to give the desired balance of load-carrying capacity. It is, however, necessary to check for strength in many cases.

In endeavouring to arrive at a suitable basis for determining strength, there appears to be no alternative to an empirical, comparative method. The form of a wheel tooth is so complicated that any attempt to determine the exact stress distribution, even under ideal conditions, appears to be a hopelessly impossible task. Fortunately, a number of wheels have from time to time broken in service and have thus provided data on which a comparative formula can be built up.

The basis of such a formula is that the resistance to tooth breakage will be approximately proportional :—

(*a*) To the true length of the curved root of the tooth,
(*b*) To the normal thickness of the tooth,
(*c*) Inversely as the normal tooth reaction for a given axial load on the worm, *i.e.*, as cos λ, and
(*d*) To the strength of the material.

The true length of the curved root will be approximately equal to the apparent length of the curved root in cross section multiplied by the secant of the lead angle ; but the normal tooth thickness will diminish in the same proportion ; hence the product of (*a*) and (*b*) will be equal to the product of the curved root in cross section and the axial pitch. Expressing the latter as module and putting l=length of curved root, λ=lead angle at "pitch diameter" (so-called) of worm, m=module, S_b=bending stress factor, and F_{aw}=axial load on worm, we have

$$F_{aw} = 1{\cdot}25 S l m \cos \lambda.$$

The constant 1·25 is equivalent to a "strength factor" corresponding to the strength factors used for spur and other gears (see British Standard Specification No. 436, 1932) when the basic stresses and speed are made equal to those for the same materials and conditions as in spur and other gears.

The strength factors for spur and helical gears range usually between 0·5 and 0·8, a value approximately twice as great for worm gears seems reasonable in view of the inherently stronger section. The above assumes that the wheel teeth are weaker than the worm threads, and this is usually true.

Collected Design Data.—The preceding formulæ may conveniently be regrouped for reference, together with the corresponding notation, subsidiary formulæ, and basic stress and speed factors.

C	Centre distance.
T	Number of teeth in wheel.
m	Module=axial pitch÷π.
D	Wheel pitch diameter=T m.
d	Worm nominal pitch diameter=2 C−D.
L	Lead of worm.
λ	Lead angle of worm on nominal pitch diameter. Tan^{-1} (L/π D).
f_{eW}	Maximum effective face width of wheel.
f_W	Actual face width of wheel.
l	Length of curved root in cross section—see Fig. 11.
S_b (basic)	Basic bending stress factor—see Table I.
S_c (basic)	Basic surface stress factor*—see Table I.
X_b	Speed factor, breaking stress—see Fig. 12.
X_c	Speed factor, surface stress—see Fig. 13.
v_s	Velocity of sliding.
M	Torque on worm wheel.
F_{aw}	Axial load on worm.
n	Revolutions per minute of worm.
N	Revolutions per minute of wheel.
μ	Coefficient of friction—see Fig. 18.
φ	Angle of friction.
E	Efficiency—see Fig. 19.

Wear.† —

Allowable wheel torque

$$M = 0{\cdot}18 \, S_c \text{ (basic)} \, X_c f_W \, D^{1.8}$$

Allowable axial load on worm=

$$F_{aw} = 0{\cdot}36 \, S_c \text{ (basic)} \, X_c f_W \, D^{0.8}$$

Notes.—f_W must not exceed f_{eW}.

S_c (basic) must be chosen for the appropriate material, for worm and wheel, and multiplied by a speed factor

TABLE I.—*Basic Stresses for Worm Gears.*

	Material.	Bending stress factor S_b, lb. per sq. in.	Surface stress factor when running with material. A	B	C	D	E
A	Phosphor-bronze sand cast	7,000	—	600*	600	700	1,400
	Phosphor-bronze chill cast	8,500	—	800*	800	900	1,600
	Phosphor-bronze centrifugally cast	10,000	—	1,000*	1,000	1,100	2,000
B	Cast iron (grey)	6,000	900*	600†	600*	600*	750†
C	0·4 per cent. carbon steel normalised	20,000	1,400	900†	—	—	—
D	0·55 per cent. carbon steel normalised	22,000	2,000	1,100†	—	—	—
E	Low-carbon case-hardening steel	27,000	6,000	4,000†	—	—	2,000†
	3½ per cent. nickel ditto	40,000	6,500	4,000†	—	—	2,000†
	5 per cent. nickel ditto	47,000	7,000	4,000†	—	—	2,000†
	3½ per cent. nickel-chromium ditto	47,000	7,000	4,000†	—	—	2,000†
	High nickel-chromium ditto	60,000	8,000	4,000†	—	—	2,000†

* Maximum permissible rubbing speed = 500ft. per min. † Should not be used except for hand motion.

corresponding to the sliding velocity and rate of repetition on that member. Sliding velocity = 0·262 dn sec λ.

Strength.—

Allowable wheel torque

$$M = 0{\cdot}625 \, S_b \text{ (basic)} \, X_b \, D m l \cos \lambda.$$

Allowable axial load on worm

$$F_{aw} = 1{\cdot}25 \, S_b \text{ (basic)} \, X_b m l \cos \lambda.$$

Note.—These apply to wheel teeth only.

For all ordinary combinations of materials, breakage

FIG. 14—*Diagrammatic Arrangement of Disc Machine.*

of a worm thread other than through fracture across the root diameter or cracking due to excessive bending in the worm shaft is almost unknown.

The lowest of the values for wear and strength represents the normal rating (continuous operation for a twelve-hour day), provided that adequate cooling, if necessary, is arranged, and given, of course, satisfactory

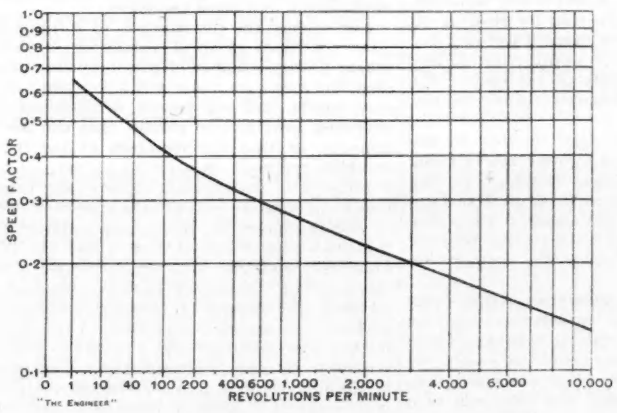


FIG. 12—*Speed Factors for Strength.*

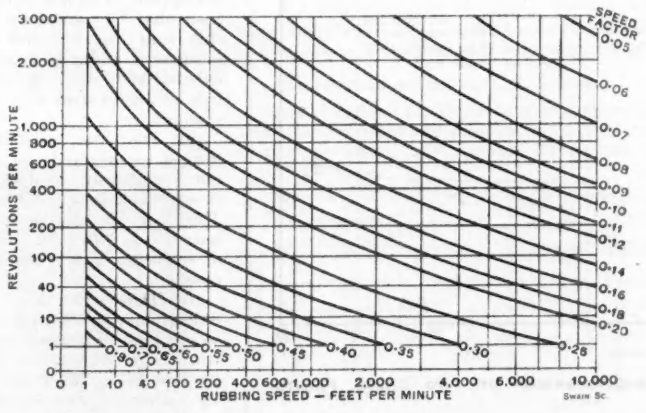


FIG. 13—*Speed Factors for Wear.*

smaller tendency of such worms to be adversely affected by deflection and consequent maldistribution of contact.

The final formula thus becomes

$$M = 0{\cdot}18 \, S_c f_W \, D^{1.8},$$

in which, it should be noted, S_c is the working surface stress factor, equal to the product of basic stress factor and speed factor.

The value of f_W which may be used in the above formula is limited to the "maximum effective face width." This is the length of the intercept, in the direction of the axis of the wheel, of the pitch plane of the worm with either the wheel rim or the circumscribing cylinder of the worm,

Experiments on Materials and Lubricants.—There are two difficulties which confront any attempt to investigate the properties of materials by testing worm gears to destruction. The first is the difficulty of ensuring correct tooth contact ; inevitable errors of workmanship in some degree, plus the much greater effect of lateral deflection of the wheel, tend towards undue localisation of contact. The second is the considerable power and long duration involved.

For these reasons the author attempted to devise an apparatus which would, so far as reasonably possible, simulate the conditions of tooth contact in regard to design, materials, workmanship, mounting, and lubrication.

* The Institution of Mechanical Engineers—February 22nd.

† Assistant Chief Engineer, David Brown and Sons (Huddersfield), Ltd.

* Formulæ in which surface failure is the limiting condition are conventionally referred to as "wear" formulæ.

curvature, loading, and surface speeds. This apparatus, which is shown diagrammatically in Fig. 14, consists of two discs, 4in. and 8in. diameter, making peripheral contact along a line optionally 0·75in. or 0·375in. long, and loaded by carrying one disc in a swinging frame and pressing it into contact with the other by a lever and jockey weight. The fixed-axis disc is driven by a pendulum-mounted variable-speed motor, and the swinging-axis disc is driven from the first optionally by gears or chain giving any desired speed ratio. A similar machine, one-half scale, was made in order to ascertain the "scale effect," but the large machine is normally used by reason of the fact that 8in. discs can be produced under similar conditions to those of gear rims made in practice, *i.e.*, by centrifugal casting.

The most unfavourable conditions are obtained when the connection is by chain, both discs then running in the same angular direction. When the peripheral velocities

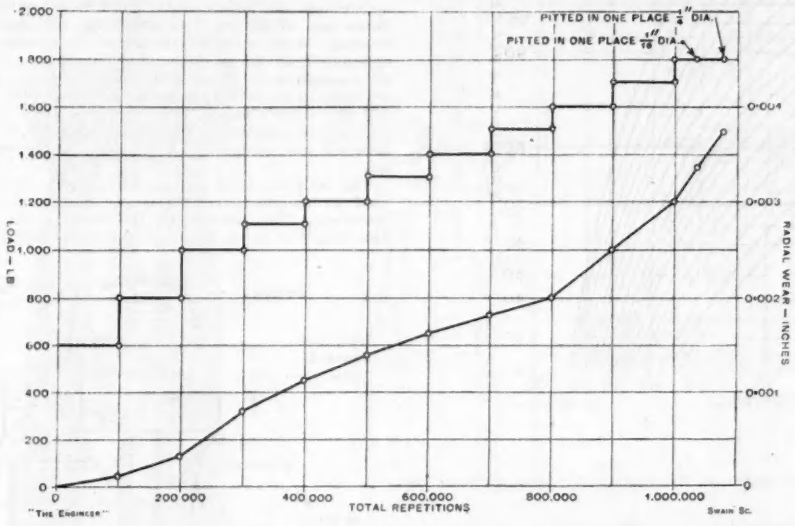


FIG. 15—*Typical Fatigue and Wear Test Results (Centrifugally-Cast Bronze).*

are equal and opposite, the viscosity drag effect is a minimum and the conditions of lubrication most severe. Radial wear and deformation are measured by a device which locates on two reference surfaces not in contact with the mating disc; the position of the test surface can be measured to 0·0001in.

The normal procedure in testing a combination of phosphor bronze (8in. disc) and hardened, ground, and polished steel, is to run the bronze disc at about 240 r.p.m. with a medium chain gear ratio, at a normal working temperature (140–160 deg.), increasing the load every 100,000 revolutions until failure occurs.

Figs. 15 and 16 show the results obtained under similar conditions of speed and lubrication from 8in. discs of centrifugally cast and sand-cast phosphor bronzes respec-

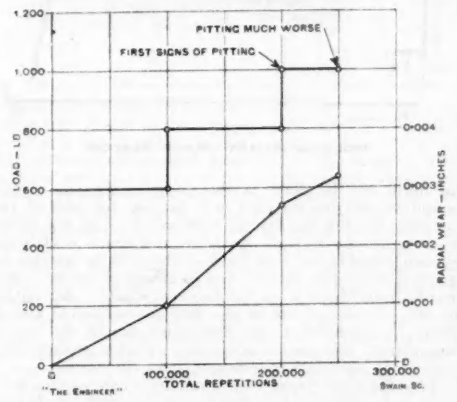


FIG. 16—*Typical Fatigue and Wear Test Results (Sand-Cast Bronze).*

tively. The loads given were taken on a face width of 0·375in.; the relative radius of curvature is:

$$R_r = \frac{l}{\frac{1}{4}+\frac{1}{2}} = 1 \cdot 333\text{in.},$$

and the surface stress factor in terms of applied load P is:

$$S_c = \frac{P}{0 \cdot 375\,(1 \cdot 333)^{0 \cdot 8}} = 2 \cdot 12\,P.$$

It will be observed that the centrifugally cast material failed by pitting after 1,040,000 repetitions during which the load increased from 600 lb. to 1800 lb. ($S_c = 1270/3820$), whereas the sand-cast material failed after only 200,000 repetitions and a load range of 600 lb. to 1000 lb. ($S_c = 1270/2120$). The total wear curves (wear includes plastic deformation during the first few repetitions of each increment of load plus actual abrasion) also show a very marked difference. By way of comparison, the maximum S_c values for which automobile rear axle worm gears are designed range between 2000 and 3000, and these usually show pitting after a few thousand miles' running (3 to 6 million repetitions).

The effect of variation in resistance to surface loading with change in surface motion was investigated by giving the smaller (steel) disc an oscillating motion, meantime rotating the large (bronze) disc uniformly. The large disc always failed by pitting at the point where the surface motion of the mating disc had its maximum velocity in the reverse direction.

So long as the surfaces are well polished and gradually "run in" under moderate load, using a reasonably good oil for the duty, steel and bronze combinations always fail by pitting of the bronze before any sign of breakdown of the oil film is apparent, *i.e.*, before any appreciable wear (as distinct from plastic deformation) or "scuffing" occurs. The surface deformation curve usually bends more or less sharply upwards just before the pitting load is reached, indicating plastic deformation to the point of internal shear. No data are yet available regarding the relative rate of increase of load on two different materials necessary to produce pitting in the same time, or the relation between load and number of repetitions for a given material before pitting occurs.

Steel and steel, or steel and cast iron, combinations show much higher friction and fail by film breakdown (seizure of surfaces) before pitting can occur.

Lack of smoothness of finish, or insufficient hardness of the steel, causes bronze to become embedded in the steel surface and rapid wear follows; but so long as the steel surface is sufficiently hard and polished, the actual wear, checked at intervals under constant load below the pitting value, has been found to be immeasurable with a 0·0001in. instrument after several millions of repetitions.

These few observations, based on the results of only a few of the large number of tests made with the disc machine, indicate the interesting results which may be obtained in investigating an almost unexplored field. Further notes on the behaviour of lubricants are given in the following section.

Worm Gear Efficiency.—The power losses in a complete gear unit are made up of two items:—

(*a*) Losses, proportional to the input power, due to tooth friction.

(*b*) Bearing and oil drag losses.

In the case of gears mounted on anti-friction bearings, oil drag represents the greater part of item (*b*), which is then a function of speed and temperature, but is independent of load. In endeavouring to predict the efficiency of a worm gear unit, the oil drag losses may be determined by experiment and results applicable to a wide range of

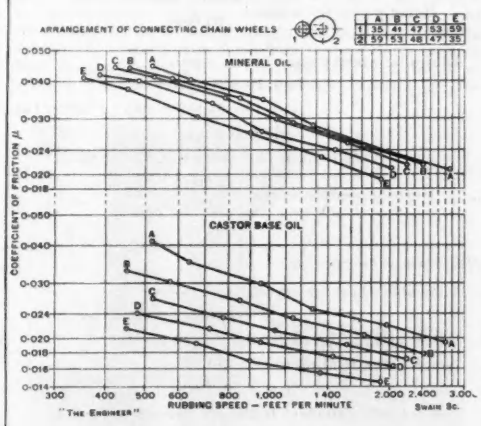

ARRANGEMENT OF CONNECTING CHAIN WHEELS
A B C D E
1 35 41 47 53 59
2 59 53 48 47 35
MINERAL OIL
CASTOR BASE OIL
COEFFICIENT OF FRICTION μ
RUBBING SPEED — FEET PER MINUTE
"THE ENGINEER"
SWAIN Sc.

FIG. 17—*Coefficients of Friction.*

conditions may easily be obtained. The principal difficulty centres round the tooth friction losses, which alone will be considered in what follows.

An easily derived expression for the net efficiency of a worm and wheel is

$$E = \frac{\tan \lambda}{\tan (\lambda + \varphi)}$$

This assumes contact at the pitch point and is not precisely true for other positions of the point of contact. The term φ, angle of friction, should strictly be an equivalent angle of friction such that

$$\tan \varphi = \mu \sec \psi_n.$$

Actually, however, the small theoretical differences due to the different positions of the point of contact, and the effect of the normal pressure angle, are completely masked by the large variations in the value of μ, and since there is reason to believe that a higher normal pressure angle tends to reduce the coefficient of friction, the expression for net tooth efficiency may for all practical purposes be left in the form stated above.

In the design of worm gears for industrial purposes the value of the coefficient of friction is of extreme importance, for in such cases the working temperature of the gear will be determined by the heat which has to be dissipated. This, in turn, is proportional to the efficiency loss. A difference between 94 per cent. and 97 per cent. in overall efficiency appears small so far as overall performance is concerned, but, nevertheless, twice as much heat will have to be dissipated in the first case as in the second. In ordinary cases, the net tooth efficiency loss, other things being equal, is almost directly proportional to the coefficient of friction, and an increase in the coefficient of friction from 0·02 to 0·03 means an increase of some 50 per cent. in temperature rise.

It is extremely difficult to measure the real value of the coefficient of friction by "input and output" efficiency tests on actual worm gears. Such tests involve the accurate measurement of the difference between two nearly equal quantities, this difference being partly masked by the presence of oil drag losses, and a further complication results from the fact that with increase of load the change in deflexion of the wheel relative to the worm alters the disposition of contact and disturbs the coefficient.

The disc machine already described offers the possibility of direct measurement of the friction between line contact loaded surfaces under a wide range of load, speed, and relative surface motion. By first ascertaining, in this way, the general behaviour of μ under different conditions, it is then possible to correlate the results with deductions from worm gear efficiency tests, and the origin of any irregular behaviour can be traced.

Determination of Coefficient of Friction on Disc Machine.—The general method consists of running the selected combination of materials and lubricant at appropriate speed and load, and observing the torque required to drive the machine.

If D is the diameter of the large disc, N its speed, M the torque required to drive it, d the diameter of the small disc, n its speed, R the gear ratio n/N (positive for chain and negative for gear connection), and P the applied load, then

$$\mu = \frac{2\,\pi\,M}{P\,(\pi\,D + \pi\,R\,d)} = \frac{2\,M}{P\,(D + R\,d)}$$

and

$$v_s = 0 \cdot 262\,N\,(D + R\,d) \text{ feet per minute.}$$

Two typical sets of curves are given in Fig. 17. The first shows the behaviour of the coefficient of friction with a castor base oil, the materials of the discs being case-hardened steel and phosphor bronze, running at a stress factor of 600, and at various speeds and chain gear ratios. It will be noted that the coefficient falls progressively as the speed increases, and that the smaller the gear ratio (*i.e.*, the greater the difference in the rolling velocities), the smaller the coefficient of friction. The "spread" of the curves indicates the susceptibility of the oil to improvement in rolling conditions.

Fig. 17 also shows the results obtained under the same conditions using a mineral oil. The values of μ are consistently higher, and the curves show less "spread."

The questions which these curves raise, and which await answers, are:—

(*a*) What determines the slope of the curves?

(*b*) What is the reason for the difference in spread and what determines its amount?

In regard to the second question, it may be observed

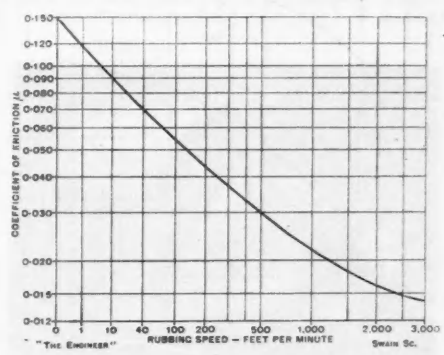


FIG. 18—*Coefficient of Friction.*

that if the improvement with increased rolling is due to viscosity drag, the mineral oil, with its higher viscosity, should have shown more spread. Conversely, under bad conditions of contract, *i.e.*, with nearly equal and opposite rolling, the castor base oil, with its assumed greater property of oiliness, should have better resisted the adverse conditions, whereas actually it does the reverse—it reacts better to favourable conditions.

Another point usually noted is that, both in the disc machine and in actual worm gears, oils of lower specific gravity give a lower coefficient of friction, and that viscosity *per se* appears to be of secondary importance. Finally, the coefficient of friction is influenced largely by the composition and structure of the bronze, but only to a much smaller degree by the steel; with some materials there is a slight gain by nitrogen-hardening the steel, but not with others; chromium plating has no effect. Materials other than bronze show enormous variations in coefficient of friction, and the lowest coefficients were obtained with glycerine as lubricant.

In addition to the problems which these observations raise, there remains the difficulty that the disc machine gives two-dimensional motion, whereas motion in worm gears is three-dimensional. Nevertheless, values obtained with relatively unfavourable chain gear ratios, using speeds and pressures similar to those obtaining in worm gear operation, agree fairly well with values obtained in worm gear efficiency tests. An averaged curve, taken from worm gear experiments, is given in Fig. 18, and it is found that the combination of values of μ from this curve and the formula previously given (plotted for convenience

in Fig. 19), gives a result very close to the measured efficiency.

Full Load Efficiency Tests.—With care, the measurement of overall efficiency by means of a pendulum-mounted motor and a well-designed Prony brake can give results accurate to about ±1 per cent. This is not particularly good, but for gears of about 90 per cent. overall efficiency, the deduced value of μ is accurate to about 10 per cent., which is much less than the variations which can be caused by inaccurate gear-cutting or mounting or excessive deflection. The disc machine will usually repeat results within about ±5 per cent.

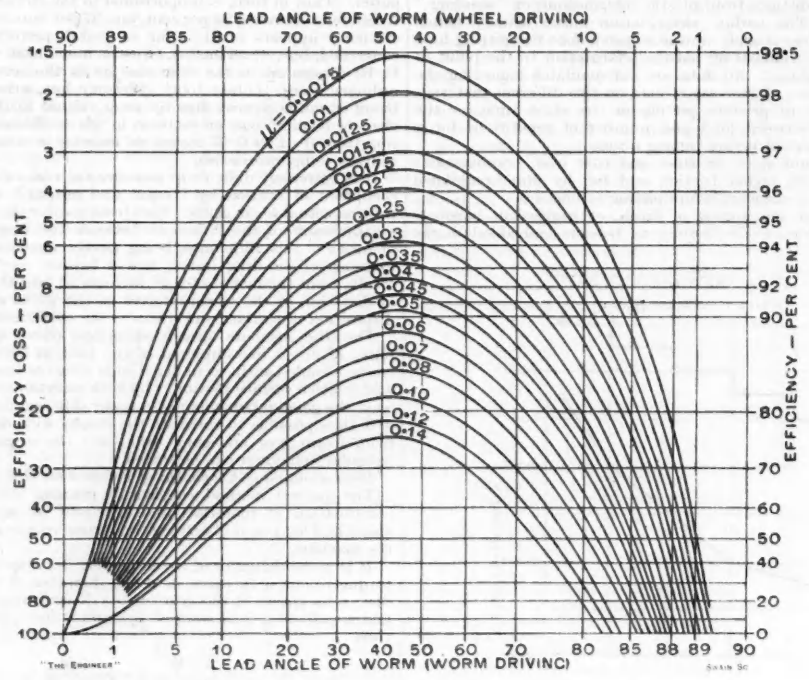
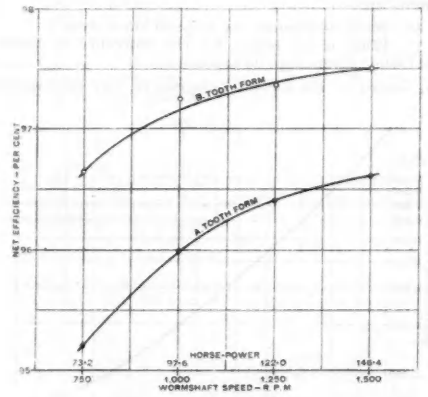


FIG. 19—*Efficiency Loss.*

For more accurate efficiency determination, carried out with a view to investigating the effect of tooth form and contact conditions on the efficiency, the author constructed a circulating power system comprising two standard rear-axle worm drive units, each having a centre distance of 7in. The worm-wheel shafts are rigidly coupled, and the parallel worm shafts are connected through a geared loading device, comprising three gears, the centre one of which floats vertically and is loaded by a lever and weights. By measuring the no-load losses, and allowing 99 per cent. efficiency for each pair of spur gears, the net tooth efficiency may be calculated. The influence of tooth form on efficiency is shown by the curves in Figs. 20 and 21. The curves designated A refer to worm gears having an involute helicoid thread form (ratio 6·5 to 1), and curves B to gears having the same dimensions and ratio, but a special (experimental) tooth form giving a higher velocity of motion of the lines of contact relative to the surfaces. The "droop" of curve A in Fig. 20 may be ascribed to the greater sensitiveness of these gears to the effect of lateral deflection of the worm wheel. The lubricant in both cases was a castor base oil.



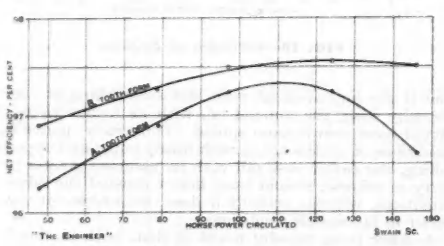

B. TOOTH FORM
A. TOOTH FORM
NET EFFICIENCY — PER CENT
50 60 70 80 90 100 110 120 130 140 150
HORSE POWER CIRCULATED
"THE ENGINEER"
SWAIN SC

FIG. 20 (*Above*)—*Net Efficiency for 7in. Centres Worm Gear (Constant Load).*

FIG. 21 (*Below*)—*Net Efficiency for 7in. Centres Worm Gear (Constant Speed).*

Performance of a Pair of High-speed Worm Gears.—By way of conclusion, the performance of a pair of high-speed worm gears, suitable for a small turbine reduction gear, will be calculated on the basis of the data given in the paper:

Centre distance (C)	=8in.
Speed of worm (n)	=5000 r.p.m.
Speed of wheel (N)	=700 r.p.m.
Ratio	=7 : 50
Worm pitch diameter (d)	=2·085in.
Wheel pitch diameter (D)	=13·915in.
Module (m)	=0·278in.
Lead (L)	=6·111in.
Lead angle (λ)	=43° 2′
Wheel face width (f_w)	=1·622in.
Rubbing speed	$=0\cdot262\ dn \sec \eta\lambda$
	$=0\cdot262\times2085\times5000\times1\cdot3680$
	=3740ft. per minute

Horse-power for Wear.—

Allowable wheel torque (wear, wheel)

$$=0\cdot18\ S_c X_c f_w D^{1\cdot8}$$
$$=0\cdot18\times2000\times0\cdot103\times1\cdot622\times114$$
$$=6850 \text{ lb.-in.}$$

[Wheel speed factor (X_c) from Fig. 13 = 0·103.]

$$\text{Horse-power for wheel} = \frac{6850\times700}{63{,}000}$$
$$=76\cdot1$$

Allowable wheel torque (wear, worm)

$$=0\cdot18\ S_c X_c f_w D^{1\cdot8}$$
$$=0\cdot18\times6500\times0\cdot055\times1\cdot622\times114$$
$$=11{,}900 \text{ lb.-in.}$$

[Worm speed factor (X_c) from Fig. 13 = 0·055.]

$$\text{Horse-power for worm} = \frac{11{,}900\times700}{63{,}000}$$
$$=132\cdot2$$

Horse-power for Strength.—

Allowable wheel torque (strength, wheel)

$$=0\cdot625\ S_b X_b D m l \cos\lambda$$

Wheel speed factor (X_b) from Fig. 12 = 0·29

Length of curved root =2·15in.

$\cos\lambda = 0\cdot7310$

$$M=0\cdot625\times10{,}000\times0\cdot29\times13\cdot915\times0\cdot278\times2\cdot15\times0\cdot7310$$
$$=11{,}020 \text{ lb.-in.}$$

$$\text{Horse-power for wheel} = \frac{11{,}020\times700}{63{,}000}$$
$$=122\cdot4$$

Allowable wheel torque (strength, worm)

$$=0\cdot625\ S_b X_b D m l \cos\lambda$$

Worm speed factor (X_b) from Fig. 12 = 0·17

$$M=0\cdot625\times40{,}000\times0\cdot17\times13\cdot915\times0\cdot278\times2\cdot15\times0\cdot7310$$
$$=25{,}835 \text{ lb.-in.}$$

$$\text{Horse-power for worm} = \frac{25{,}835\times700}{63{,}000}$$
$$=287\cdot1$$

Continuous rating = least of four values = 76 h.p.

Efficiency.—

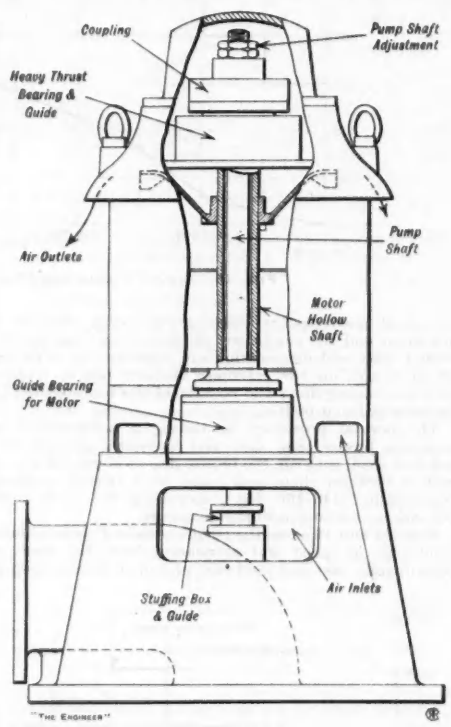
Coefficient of friction (μ) from Fig. 19 = 0·013

Tooth efficiency =97·4 per cent.

Hollow Shaft Pump Motors.

A NEW hollow-shaft motor, built in sizes ranging from 15 to 60 h.p. at 1500 r.p.m., has been introduced by the British Thomson-Houston Company. The two principal features of the machine are a hollow shaft and heavy-duty thrust bearings, which enable the total thrust of the pump to be taken by the motor. In the case of the normal vertical motor pump drive, a standard vertical motor drives the pump below it, through a flexible coupling, and the pump thrust and weight are taken by the pump thrust and guide bearings situated above the delivery head. With this arrangement the motor usually stands on a pump stool of appreciable height, but with the new hollow-shaft, heavy-thrust pump motor, the top thrust bearing of the pump and flexible coupling are eliminated, with the result that the motor stands on a much shorter and sturdier stool. The pump shaft is taken up through the hollow motor shaft to a coupling which forms part of the machine above the top motor thrust bearing. Some of the advantages of the arrangement are apparent from the accompanying illustrations, which are self-explanatory. All adjustments of the pump clearances are made at the top of the motor in an accessible position, and the thrust bearing is easily inspected. To ensure satisfactory operation the thrust bearing is liberally designed and adequately lubricated, the oil wells being large.

The coupling is of the usual pin type, and may be used in conjunction with pump shafts with screwed couplings. This necessitates the motor running in one direction, but in the event of the motor being reversed



HOLLOW SHAFT PUMP MOTOR

no harm can be done to the pump, since one of the couplings will unscrew and will lift the top half of the coupling clear of the driving bottom part. As the motor is designed for vertical operation and has a ventilating system suitable for that kind of duty, it is possible to adopt a streamline exterior and to discharge the air downwards from the rim of the top end shield. Air enters at the bottom or side of the bottom end shield and is drawn upwards by a cast aluminium fan at the top of the motor. The smooth streamline exterior is completely drip proof, and even rain cannot enter the motor.

The stator has taped end windings, which are specially treated to withstand moisture and oil, and are braced to enable them to withstand the shocks produced by direct starting, the rotor being of the double squirrel-cage type to reduce the starting current. Single squirrel-cage rotors with a slightly higher efficiency are, however, also used. Although the range of motors covers 15 to 60 h.p., mountings of only two dimensions are adopted, thus enabling the pump maker to interchange motors for the same pump head over an appreciable range of horse-power. To assemble and dismantle the units it is only necessary to remove four bolts, when the top end shield may be lifted out complete with the rotor and bearings. The top bearing is a heavy ball thrust unit, whilst the bottom bearing is of the roller type. The latter merely serves as a guide bearing and is arranged so that the inner race with the rollers in position will lift clear of the outer race, which is left in the end shield, both bearings being assembled on sleeves which are easily removed from the shaft.

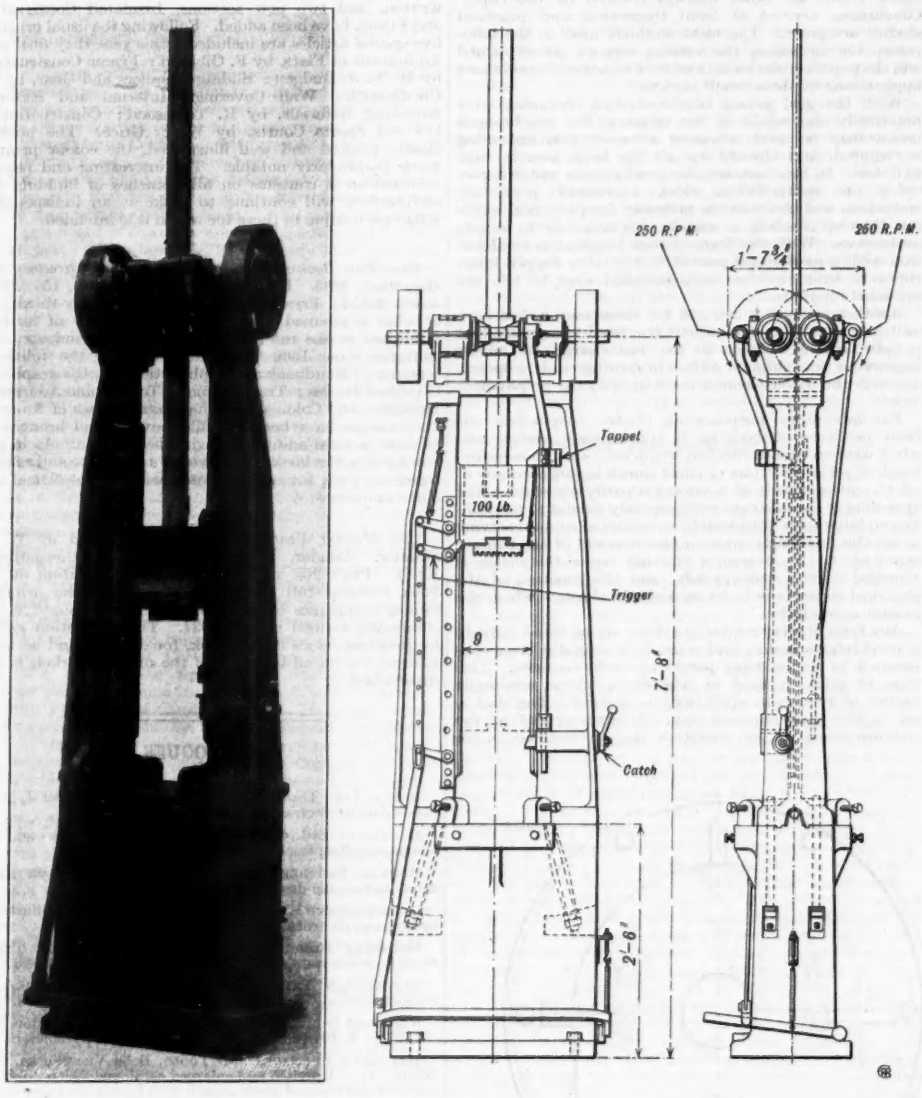
A Fast Drop Hammer.

A LIGHT drop hammer which has recently been made by Bretts Patent Lifter Company, Ltd., of Foleshill, Coventry, is illustrated by the accompanying drawing and half-tone engraving. It is a comparatively small machine, having a tup of only 100 lb. weight, but it is capable of delivering blows at the rate of 130 per minute, with a fall of 18in. The maximum fall is 3ft. and the minimum 1ft.

The hammer is lifted by the frictional engagement of

two rolls, rotating in opposite directions, on a maple wood board 3in. wide by ¾in. thick. The board is held in a recess in the hammer by a steel wedge. The grip of the rolls on the board is effected by mounting them in excentric bearings, the excentricity of which is only ⅛in. The excentrics have arms to which there is attached a vertical bar, which, of its own weight, will press the rolls against the board to raise the tup. At the top of this rod there is a tappet, which engages with the top of the tup and lifts the rod at the upper end of the stroke. This releases the rolls from the board and the tup would be free to fall were it not for the trigger controlled by the foot treadle. At the same time the weight of the rod is taken by a catch at the bottom, so that although the lifting rolls continue to revolve, they do not touch the board. By depressing the treadle the trigger is released and the hammer falls to effect the blow. Just at the moment of impact the tup frees the rod catch, the rod falls and the excentrics make the rolls grip the board to raise the weight, so that the cycle is repeated. If the treadle is held down the blows are, of course, repeated indefinitely.

The machine is substantially built, with guides of box section fitted on to machined faces on the block and strapped down by heavy tie bolts. It has a total weight of 32 cwt., and requires 2 h.p.



FAST DROP HAMMER

A Crane Safe Load Indicator.

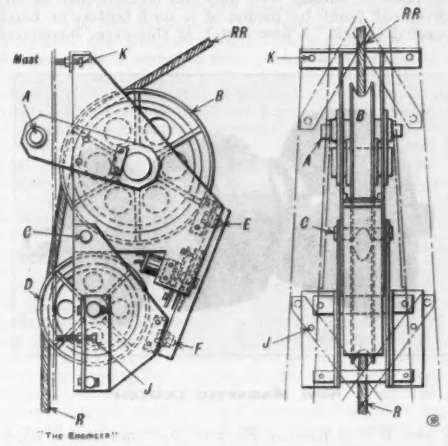
THE two accompanying engravings illustrate a safe load indicator supplied by Wylie Safe Load Indicators, Ltd., of 3-4, Clement's-inn, London, and made by Sir William Arrol and Co., Ltd. It differs from many of the devices of a similar nature which have at one time or another been described in these pages by the fact that the load instead of being balanced by a spring through a system of levers is taken by a compression strut. The bending strut is a spring steel bar which offers itself endwise to the load and provides a big movement crosswise by bending. Force-reducing mechanism is not required. The ends of the bar are solidly bolted to the compression heads and the movement of the heads is so small that frictional effects can easily be eliminated by appropriate design. The switch and other electrical parts operated by the indicator are properly enclosed, but the makers claim that the other parts require protection no more than do the working parts of the crane itself. The strut itself and other machined parts are protected by metallisation with aluminium to render them immune from corrosion, and a case can be fitted if desired.

The two illustrations show the type of this indicator suitable for a Scotch derrick crane.

The indicator is hinged on axle pin A and houses the usual mast pulley B, and also a deflector pulley D in its lower part, which is hinged to the upper part at C and strutted from it by the Wylie bending strut E F. The downward lead R of the lifting rope is deflected by the pulley D, which it presses outwardly, thus opposing the tendency of the indicator to swing downwardly as a whole about the pin A under the pressure on pulley B of the outward lead R R. If the indicator were free, it would swing about A up and down with R R, but stop K is set to contact with the mast when the jib is at the maximum radius at which maximum load may be lifted. As the jib is raised from this position, over the maximum load range, the top part of the indicator acts simply as a fixed bracket resting on K and the pressure on the pulley D, and hence the thrust on the strut E F remains constant. As the jib is lowered from maximum load radius, the stop J comes into action and the pressure on it increases as R R inclines downwards. Pressure on the stop J causes a thrust on E F additional to that due to the pulley D, and since the total thrust which causes a signal is a fixed amount, the load on the crane must diminish as the jib is lowered. The rate at which the load diminishes is greater, the greater the distance of J from C, and J is therefore definitely fixed to suit the approved loading schedule. The friction in the pulleys is used to assist the signals to be given when the crane is working towards danger (*i.e.*, lifting or derricking out), and to stop them when the motion is reversed.

The bending of the strut causes contact to be made in an electrical circuit, and further bending causes another contact to be made. By this means a green pilot light is burning while the load is a safe one; a red warning light glows when the load near the maximum is being lifted, and a buzzer is operated when the crane is overloaded.

SAFE LOAD INDICATOR



DESIGN OF SAFE LOAD INDICATOR

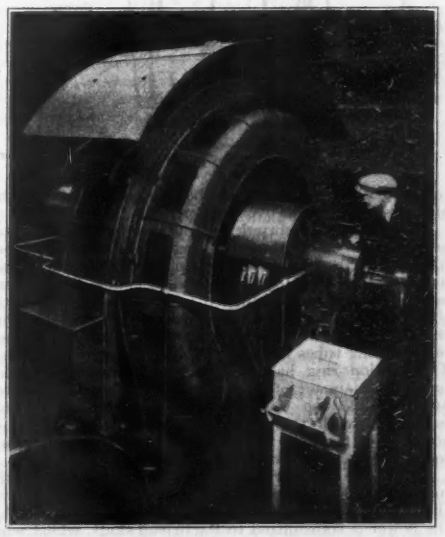
These signals are those obtained on an electric crane, and they are energised from the crane supply. On hand cranes the buzzer is energised from a battery, and on steam cranes the indicator can be linked with the whistle.

It is claimed that the action of this indicator is dead-beat, sensitive, and accurate. In proof of this claim it is said that by derricking a suitable load out until the green safe light is just changing to red, and then swinging the load slightly, the signal will become green when the load swings inwards, and change to red as it swings outwards. If a safe load is snatched, the red light will show momentarily, but there will be no continued oscillation.

Hyposynchronous Motor Rolling Mill Drive.

SINCE the hyposynchronous motor was introduced by Laurence Scott and Electromotors, Ltd., of Norwich, considerable progress has been made in the direction of utilising this type of machine for driving rolling mills, and the accompanying illustration shows a 245 r.p.m. machine built for this duty. It is rated at 600 h.p. at 5000 volts, and is provided with a separate motor-driven Heyland exciter to give a leading power factor. Together with a somewhat smaller machine it serves to correct the power factor of the whole works when working under the fluctuating load conditions. As it gives a constant reactive kVA, the correction is independent of the load which increases the slip, as in the case of an ordinary induction motor, and the machine therefore operates below synchronism. The self-regulation of the reactive kVA is independent of the temperature rise, so that the necessary power factor correction can be maintained without having to adjust exciter regulators. A stator wound like that of an induction motor and an armature similar to that of a Laurence Scott D.C. machine, form the small exciter, which transfers the major portion of the energy it absorbs to the main motor, having an efficiency in most cases equal to that of a straightforward induction machine, andhigher than that of a compensated or autosynchronous motor.

With the exception that when the machine has reached full speed, a change-over switch cuts out the starter and introduces the exciter into the rotor circuit, the hypo-

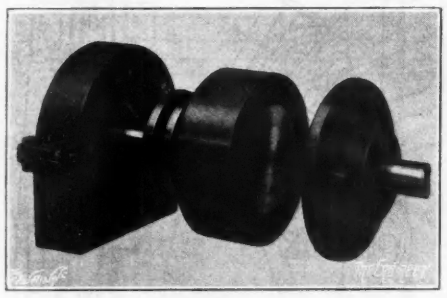


600 H.P. HYPOSYNCHRONOUS MOTOR

synchronous motor is started in the same way as an ordinary induction motor, and as the power factor correction is automatic once the machine has been started, it requires no attention.

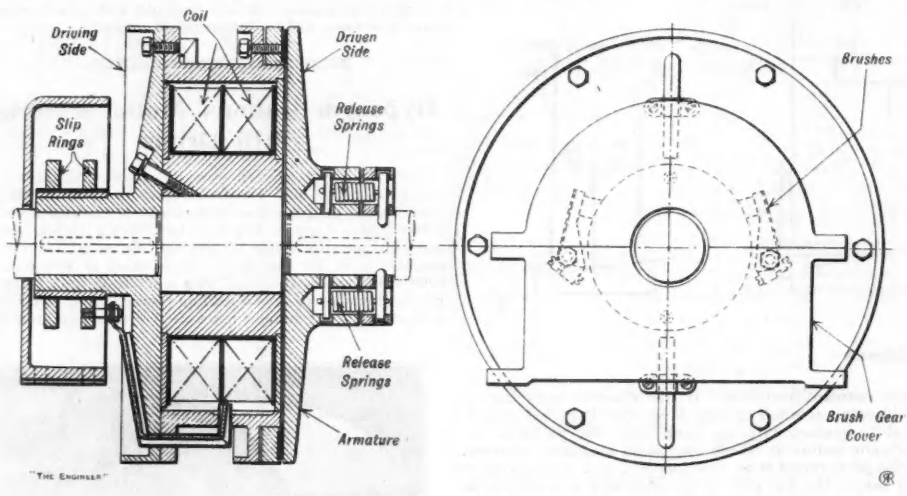
A New Magnetic Clutch.

MAGNETIC clutches have many applications, such as in connection with machine tools, screw-down gearing for rolling rolls, compressors, &c., and they offer the important advantage that they can be controlled at any convenient point by means of a push button or hand-operated switch. A new clutch of this type, introduced



NEW MAGNETIC CLUTCH

by the Witton-Kramer Electric Tool and Hoist Works of the General Electric Company, Ltd., Magnet House, Kingsway, W.C.2, is manufactured in standard sizes ranging from 7in. to 57in. in diameter, with a safe capacity at 100 r.p.m., ranging from 0·45 to 540 h.p., and a power consumption from 60 to 1500 watts. As shown in the accompanying illustrations, the clutches comprise a main body keyed to the driving shaft and provided with exciting windings, a friction face, slip rings, and an armature or sliding portion mounted on the driven shaft and provided with release springs. The main body is composed of high permeability steel, accurately machined, and the coil contained within it is former-wound on a



ARRANGEMENT OF MAGNETIC CLUTCH

central core. As the coil is liberally rated, it is capable of continuous service over long periods.

The slip rings are shrunk on to a micanised hub mounted on the main body of the clutch, and the lever-type holders, which carry the brushes which supply current to them, are designed to eliminate chatter and to enable the pressure on each brush to be adjusted independently. Both the slip rings and brush gear are enclosed by a cover, while the connections from the slip rings to the coil are enclosed in insulating tubes fixed to the main body of the clutch. The friction ring has a Ferodo strip, and in clutches having a diameter of 12in. and above the ring and coil are assembled so that they can be removed without interfering with the shafts or clutch armature, which consists of a high permeability steel disc accurately machined and fitted with release springs.

When the excitation current is switched on, the magnetic pull draws the armature into firm contact with the friction face on the main body of the clutch, so that the power is transmitted to the driven shaft, whilst when the current is switched off the armature is automatically disengaged from the friction face by the release springs.

Synchronous Time Motors.

SMALL self-starting synchronous time motors, such as are employed in time switches, meters, recording instruments, and other timing devices, are dealt with in a paper read by Messrs. W. Holmes and E. Grundy before the Institution of Electrical Engineers on March 1st. Hand-started motors, as used in domestic clocks and devices which require external starting means, are excluded, in order to reduce the length of the paper, which gives a resumé of some of the self-starting designs available, and includes test results. The hysteresis type of motor, as recently investigated by the authors, is considered, and from the results obtained by them endeavours are made to substantiate Steinmetz's theory of this type of motor as expounded in 1900. Various new materials, such as cobalt steel, aluminium-nickel steel, and magnetic silver alloys, are considered, and the hysteresis coefficients, as determined experimentally, are given. The nine designs of small motors described have been chosen to give typical examples of the motors available, and some of the difficulties of design and manufacture are explained. The question of "running-in" torque, which is a very important factor, and the use of permanent magnets as synchronous motor rotors are other matters covered by the paper. Conclusions arrived at from theoretical and practical studies are given. The tests methods used in the laboratory for measuring the various torques are explained and the paper concludes with some brief notes on specialised applications of these small motors.

With the grid giving time-controlled frequency over practically the whole of the country, the synchronous motor may be used wherever accurate time-indicating is required, and already its use has been seen in time switches. In this instance the synchronous motor supersedes the spring-driven clock movement previously embodied, and obviates the necessity for periodical winding, thereby effecting a considerable economy to supply authorities. With this form of time keeping, in combination with a mechanical reserve to tide over supply interruptions, time switches once installed may be left unattended for years.

Another increasing demand for these motors has been in house service meters where the fixed charge amount is collected, in addition to the unit charge, the motor registering time through a train of gearing, and co-operating with the meter element train to open the prepayment switch.

For laboratory purposes an electric stop-watch has been produced embodying a synchronous motor, and when used on time-controlled frequencies for the measurement of periods of time of short duration, an accuracy of up to one-twentieth of a second is easily obtained. The operation of this instrument is precisely similar to the well-known laboratory stop-watch, an electrical contact serving to set the pointer in rotation and removal of the contact arresting it. To overcome starting errors the motor is arranged to run continuously, and the function of the electrical contacts is to let in a clutch through which the pointer is connected.

Any form of relay requiring a delay action could embody a synchronous motor, and some have actually been constructed to give a delay period up to 30 minutes. This type of relay is used in workshops where automatic timing of repetition operations is desired. The dial is set to the time required, say, 15 minutes, and at the commencement of an operation the synchronous motor driving the relay is energised. At the end of the predetermined interval of 15 minutes, the relay closes an electrical contact, which may be arranged to illuminate a signal lamp or sound an alarm. The device is usually made automatic, whereby it is self-resetting, ready to repeat the cycle.

For electric clocks of large dial sizes, for which a fair amount of mechanical energy is required, and situated in not easily accessible places, these self-starting motors may be used in place of the usual hand-starting type.

Synchronous motors could be used with advantage for clocks on board ship, for they can be run from a special alternator with combined mechanical and electrical means for regulating the frequency. The frequency could be adjusted for advancing and retarding the clocks when the ship is moving in an easterly or westerly direction respectively.

In any instruments in which the recording of quantities, such as kilowatt demand, barometric pressure, steam pressure, &c., is required, the small motors are adapted without difficulty to provide the timing mechanism.

The well-known spring-wound hour meter could be superseded by one having a synchronous motor drive, to register the total time that a circuit has been closed or to register the number of hours that any particular machine has been in use.

In the works with which the authors are associated, these motors have been used for very many applications, and one mentioned is the automatic filling of D.C. meter mercury baths. Again, in the motion study experiments, a synchronous motor timing device has been designed which, in conjunction with a cinematograph camera, times works operations to one-hundredth of a second.

Television has already claimed the synchronous motor, and experiments utilising the self-starting type for scanning are being conducted.

Developments are being made to use the synchronous motor as a primary factor in the timing of watch escapements by stroboscopic methods, and promise is indicated of a considerable economy in the length of time required for the observations and regulation.

BOOKS OF REFERENCE.

Specification, 1935. Edited by F. R. S. Yorke. London: The Architectural Press, 9, Queen Anne's-gate, S.W.1. Price 10s. 6d. net.—Several alterations and improvements have been made in the new edition of this book, all the contents have been revised, ten of the existing sections re-written, and two new sections, Insulated Construction and Floors, have been added. Following the usual practice, five special articles are included; this year they deal with Equipment of Flats, by F. Gibberd; Frame Construction, by W. E. J. Budgen; Sliding Members and Gear, by W. Goodesmith; Wall Coverings, Internal and External Surfacing Materials, by R. Townsend; Construction of Covered Sports Courts, by W. S. Grice. The book is clearly printed and well illustrated, the colour printing being particularly notable. The interesting and reliable information it contains on all branches of building and architecture will continue to make it an indispensable reference volume to those for whom it is intended.

The Blue Book: The Electrical Trades Directory and Handbook, 1935. London: Benn Bros., Ltd., 154, Fleet-street, E.C.4. Price 25s. net.—This is the fifty-third issue of what is claimed to be the only directory of its kind published in the interests of the electrical industry. It contains some 1500 pages, divided into the following sections:—Handbook; Alphabetical; Geographical; Classified Trades; Trade Names; Telegraphic Addresses; Dominion and Colonial and the United States of America. Its contents have been carefully revised and brought up to date, several additions having been made. As in previous years, the book will be found a complete and reliable reference work for all connected with the electrical and allied industries.

The Mining Year Book, 1935. Compiled by W. E. Skinner. London: W. E. Skinner, 15, Dowgate-hill, E.C.4. Price 20s. net.—The forty-ninth edition of this book contains full particulars of 1400 of the principal mining companies of the world, including some 220 new companies formed during 1934. The reputation gained by previous issues of the book, for detailed and accurate information on all branches of the mining market, is well maintained.

CATALOGUES.

ROYCE, Ltd., Trafford Park, Manchester.—Booklet J, giving particulars of electric cranes.

HADFIELDS, Ltd., Sheffield.—A leaflet giving sizes and forms of non-corroding steel road studs.

HOLMAN BROTHERS, Ltd., Camborne.—Leaflets on single-drum and double-drum electric hoists.

GLENFIELD AND KENNEDY, Ltd., Kilmarnock.—An illustrated brochure of control sluices for rivers and reservoirs.

HORSELEY BRIDGE AND THOMAS PIGGOTT, Ltd., Tipton, Staffs.—New catalogue of pipes for water, gas, sewage, &c.

CATERPILLAR TRACTOR COMPANY, Peoria, Ill., U.S.A.—A booklet entitled "Special Attachments for Special Needs."

NEGRETTI AND ZAMBRA, 38, Holborn-viaduct, London, E.C. —List No. E/10 of electrical thermometers and pyrometers.

BRAYSHAW FURNACES AND TOOLS, Belle Vue Works, Manchester, 12.—A revised and enlarged catalogue which illustrates many of the types of plant supplied for ferrous and non-ferrous heat treatment.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

PETER STUBBS, Ltd., Warrington, has appointed as representative in the Eastern Counties Mr. W. A. R. Davies, of 58, Argyll-avenue, Luton.

AT a meeting of the board of English Steel Corporation, Ltd., held on February 21st, Mr. F. Pickworth, the secretary of the corporation, and Mr. A. G. E. Briggs, sales manager, were appointed special directors.

THE Bristol office of Messrs. A. P. I. Cotterell and Son, MM. Inst. C.E., MM. Cons. E., consulting engineers, 54, Victoria-street, S.W.1, formerly at 28, Baldwin-street, is now 18, Orchard-street, Bristol (telephone No. 23,638).

CONTRACTS AND ORDERS.

The Editor is always happy to print short announcements of contracts and orders in this column provided they are sent to him in time to have news value and that they are likely to interest readers.

JOHN M. HENDERSON AND CO., Ltd., King's Works, Aberdeen, have received an order for two 2-ton electrically driven transporter cranes for the East Indian Railway.

THE HYDRAULIC COUPLING AND ENGINEERING COMPANY, Ltd., Isleworth, has received from the authorities responsible for the Mogden public works an order for six large-sized Vulcan-Sinclair hydraulic couplings. These couplings are required for the Diesel-engined compressor drives.

CHEMICAL ENGINEERING CONGRESS OF THE WORLD POWER CONFERENCE.—This Congress is to be held under the auspices of the International Executive Council of the World Power Conference, and will take place at the Central Hall, Westminster, from June 22nd to June 27th, 1936. The Organising Committee is under the chairmanship of Sir David Milne-Watson, and the President of the Congress will be the Right Hon. the Viscount Leverhulme. The Grand Council comprises representatives of the various scientific institutions, research associations, and Government Departments interested in chemical engineering. The technical programme has been arranged in six sections:—Chemical Engineering Projects; Chemical Engineering Plant Construction; Fuel, Heat, and General Problems in Chemical Engineering; Administration and Works Organisation in Chemical Engineering; Trend of Development in Chemical Engineering; General Aspects. Full details of the Conference are obtainable from the administrative offices at 54, Victoria-street, S.W.1.

Markets, Notes and News.

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quotations are f.o.b. steamer. A comprehensive list of the prices of materials mentioned below will be found on the next page.

The Continental Tube Cartel.

Great interest has been aroused by the news that the Continental Tube Cartel has collapsed owing to its inability to reach an agreement regarding quotas. It has always been regarded as one of the strongest of the Continental steel trade Cartels, and it formed the backbone of the International Tube Cartel of which the British, American, and Canadian tube makers are also members. It is reported that the Cartel broke down because it was unable to meet the German claim for an increased export quota as a result of the transference of the Saar tube works to Germany. This, however, can scarcely have been the case, since practically all the Saar production has been included in the German export quota. One works has apparently lost an export quota in France as a result of the return of the country to Germany, and, naturally, applied for an increased export allotment in other markets to make up for the deficit, but this in itself was scarcely sufficient to cause a breakdown of the organisation. The International Tube Cartel agreement is to be renewed on March 31st, when special meetings of the countries interested will be held, and it is known that several members, including the British, have demanded increased export quotas. It can be understood, therefore, that the Continental tube manufacturers desired to get their quotas in their own Cartel increased before this meeting. It is suggested that the International Cartel will continue in existence whatever happens to the Continental Cartel; but this is highly improbable, since the former could exercise little control if the tube industries in each country were not organised in this way. Probably none of the interested tube industries desires to see the International Cartel broken up, and, according to reports, fresh negotiations are proceeding behind the scenes in an effort to save the Continental Cartel. It was in July, 1926, that this organisation was formed for a period of fourteen years. It included works in France, Germany, Belgium, Poland, and Czechoslovakia. It is stated that the international agreement will be observed until March 31st. If the Cartel is not renewed it may have an important influence upon the affairs of the Continental Steel Cartel, which is also to be renewed at the end of March.

The Pig Iron Market.

New business in pig iron has been rather scarce for the past week or two, but since the end of the month hopes of more active markets have been aroused by an increase in the volume of inquiry. This revival of interest seems to be common to all districts, but in any case the makers hold a strong position, since they are not overburdened with stocks, and the busy season of the year is approaching. On the North-East Coast the production is being absorbed by the local demand and the Scottish foundries' requirements. It is understood that there is little iron in the producers' hands, so that any increase in demand might necessitate an addition to the five furnaces now producing Cleveland iron. Business with Scotland has not developed to the extent which was anticipated earlier in the year, but this has been made good to some degree by the increased needs of the local users. As the home market takes practically the whole make of Cleveland, the producers are showing little interest in export trade. In the Midlands the steady conditions which ruled during February have extended into March, but it is understood that some of the big consumers will shortly be coming into the market to renew contracts, and most makers report an increased inquiry from the smaller users. Some improvement has been noticeable in the requirements of the Midland light castings trade, but this still fails to develop according to expectations. There has been only a poor demand for forge iron for some time, and as a result the stocks of this description of pig iron amount to a considerable tonnage. A slight improvement in the bar iron trade early in February which led to hopes that some of these stocks would be liquidated did not last long enough to have any appreciable effect upon the position. In Scotland the situation has not varied during the past week or two. Consumers seldom commit themselves to important quantities, but the volume of small orders amount in the aggregate to a substantial tonnage, and the producers seem well off as regards work in hand. The market for hematite has been on the quiet side, principally because so many important users have covered their requirements. A fair export business, judged by modern standards, has been transacted of late, but some fear is expressed that the new system of licences imposed by the Italian Government may injure trade with that country.

The Midlands and South Wales.

Buying on an active scale developed recently in the Midland steel market, but as the demand was chiefly concentrated upon structural material, this may have been due to anticipations that the British steel makers at their quarterly meeting would advance prices for this material. There is no doubt that orders totalling a considerable tonnage were placed as a result of these rumours, which circulated in most districts. The talk of higher duties upon imported steel and the knowledge that the Import Duties Advisory Committee is considering the steel makers' application for heavy increases, has reduced the market for Continental steel to a state of stagnation. It is surprising, perhaps, that this has not led to a stronger demand for British steel, but outside the orders for sections just referred to users seem to be satisfied by drawing upon their stocks and with deliveries they are taking against contracts. Business in plates fails to develop strength. The demand for boiler plates in particular has been disappointing. The controlled price of £9 7s. 6d. d/d Midlands and subject to rebate to the consumers in the British steel makers' rebate scheme, does not provoke antagonism amongst consumers; but most of them seem to have covered their requirements for some time ahead. The sheet makers are not working at anything like capacity; but the demand, at least, is steady and would be distinctly good if only the export side of the market were to become more active. The makers of small bars and strip are fairly well employed, but they anticipate a considerable improvement in their business if the duties upon imported material are raised. Continental material is offered at the rate of £7 1s. 6d. for bars, and £7 10s. to £8 10s. for strip, delivered and including duty, whilst the associated English makers quote £8 12s. for small bars, less a rebate, and £9 7s. for strip. Works outside the Association quote about £1 less. Although the market in South Wales has been quiet, production has been well maintained. The improved position of the shipbuilding and structural engineering industries has led to an increased demand upon the heavy steel works. On the other hand, the quieter conditions in the tin-plate industry have reacted upon the request for semis. The tin-plate works are now operating at about 50 per cent. of capacity, but recently the sales have considerably exceeded this figure.

The North-East Coast and Yorkshire.

The steel works on the North-East Coast have been well employed since the beginning of the year, and lately there has been some expansion in the demand. New business has been irregular, but the aggregate tonnage of orders reaching the works has amounted to a considerable figure. Orders for rails and railway material have not been given out on the scale anticipated, but the local view is that this business will mature later on. Most of the rail mills are well occupied, although some of them are reaching the end of important contracts. The demand for shipbuilding material, whilst rather better than at this time last year, is on the light side, and for the time being there seems little prospect of an improvement in this branch, as comparatively few shipbuilding orders have been received by the yards on the North-East Coast. The constructional engineering concerns, which are providing valuable support for the steel works, are engaged upon important contracts both for home and abroad, and their requirements of structural steel have been particularly heavy. The black sheet trade has shown some improvement recently, but this is the result of a better home demand and export business shows no sign of expanding. Business in galvanised sheets also has been quiet for some time and the makers have to rely upon the home market, which shows a tendency to shrink. The general situation in the Yorkshire steel industry is satisfactory, although the high rate of operations which was maintained at the end of the year has been somewhat relaxed. Nevertheless, the production of basic steel is at a good level; whilst recently there has been more inquiry in the market for acid steel. An active demand exists for special steels and little sign of a decrease in the use of stainless steel can be seen. On the other hand, contrary to expectation, business in tool steel has fallen off. The re-rolling mills in the Sheffield district are nearly all well employed and can face the future with confidence, as they have good order books and the busy season of the year is approaching. The engineering works recently have taken some important orders for machinery and are providing an outlet for good quantities of high-class steels. Work for the railway companies is keeping the plants busy, several orders having been placed for tramway rails and supplies.

Current Business.

Tenders are invited by William Cory and Sons, Ltd., for two self-trimming colliers of 4200 tons and 2600 tons. During February nine vessels were launched by Scottish shipyards, the total tonnage being 23,039, making the total launched this year 34,000 tons. The London Passenger Transport Board has placed orders for sixty-eight four-wheeled trollybus chassis with Leyland Motors, Ltd., and for fifty-two six-wheelers with the Associated Equipment Company, Ltd. At a recent meeting the Stoke-on-Trent City Council agreed to take a supply of coke-oven gas from the Shelton Iron, Steel and Coal Company, Ltd., at the following scale:—For the first million cubic feet per day, 6½d. per 1000 cubic feet; for the second million per day, 6d. per 1000, and for any quantity over two millions per day, 5½d. per 1000 cubic feet. The agreement is for fifteen years. It is expected that the oil-from-coal plant of Imperial Chemical Industries, Ltd., will be working to capacity by mid-summer and producing motor spirit at the rate of 30 million gallons per annum. The Department of Overseas Trade reports that the following contracts are open for tender:—Johannesburg: Tram track material, including 19 tons coach screws, 5 tons grooved rail fish-plate bolts and nuts, 2600 steel flat tie bars and nuts, 570 pairs of steel grooved tramway rail fish-plates, and 960 tons of grooved tramway rails, all short tons (Johannesburg, March 21st). Argentine State Oilfields Department: 25,200 m. of steel casing pipes, various diameters, with couplings, shoes, &c. (Buenos Aires, March 2nd.) Argentine State Railways: Twenty electrical train heating equipments, with 100–110-volt generators with heaters, cables, and all accessories (Buenos Aires, April 29th). Indian Stores Department: One cold-starting crude oil engine-driven air lift cum centrifugal pumping plant, capable of delivering 12,500 I.g.p.h., against a total head of 48ft. (New Delhi, March 18th). Lahore, North-Western Railway: Fifteen superheated boilers for "S P/S" class (4–4–0) type locomotives (Lahore, April 8th); three superheated boilers for "H.P./S" class (4–6–0) standard B.E.S.A. engines, and eighteen superheated boilers for "H.G./S" class (2–8–0) standard B.E.S.A. engines (Lahore, April 15th). A local firm in Toronto, Canada, requires quotations from United Kingdom makers of electrical steel sheets for the manufacture of motor rotor and stator laminations.

The Copper Market.

The copper market at the end of last week developed a cheerful tone, the change in sentiment being due to the announcement that representatives of the Rhodesian and European copper companies were sailing for New York in order to take part in a conference with the American producers with a view to deciding upon a scheme for the restriction of production. It was known that unofficial discussions had been going on for some time, and the market immediately jumped to the conclusion that sufficient unanimity had been obtained to warrant a meeting. The change in sentiment was probably the more violent because, until the news was published, the market, after a period of optimism, had become very dubious as to the possibility of any plan being formulated which would be acceptable to all the producers. The announcement by the Royal Bank of Canada that schemes have been discussed by the copper producers for the formation of a pool to purchase the copper produced by the Canadian nickel industry as a by-product and to hold it off the market until conditions warrant its sale, has also had something to do with strengthening the tone of the market. In spite of the improved outlook, however, buying by consumers has not been active. British Government Departments have purchased a certain amount, and German consumers seem to have more funds at their disposal with which to satisfy their copper requirements. Speculative dealings in the standard market have increased considerably this week as a result of the change in the electrolytic copper market. Conditions, however, appear sound, and the stocks in warehouse now amount to 50,540 tons of refined and 11,678 tons of rough copper.

Tin Price Fluctuations.

Fluctuations in the tin prices during the past fortnight have probably been more violent than any dealers in the market anticipated. The fall which was referred to last week brought values down to £215 15s. for cash and £211 10s. for three months. At these figures interests which usually support the market and which are technically known as "the group," began to buy on a fairly substantial scale. As a consequence, at the end of last week prices jumped about £5 in a day, and although this did not by any means restore the position, it indicated the danger of bear selling, since nothing has occurred to weaken the control exercised by the International Tin Pool and the interests associated with it. The statistics issued at the end of February by Mr. W. H. Gartsen showed an increase of 4824 tons in the visible supply. As, however, the statistics for February included for the first time 7476 tons of tin which was part of the Buffer stock held by the International Tin Committee, the position of the metal was considered satisfactory. The carry over in the Straits Settlements was down to 1197 tons from 2070 tons at the end of January, whilst at the Arnheim smelter it showed an increase of 2577 tons from 1771 tons. The supplies last month were 11,580 tons, against 8452 tons, and the deliveries 6756 tons, against 7804 tons. It will be seen, therefore, that the statistics are of a rather contradictory character, but the market appeared inclined to put the best complexion upon them. So far as the demand from consumers is concerned, American buyers have shown a moderate interest in the market, but transactions with the Continent have been on a meagre scale.

Non-ferrous Metal Average Prices.

It is not surprising that the average prices of the principal non-ferrous metals dealt in on the London Metal Exchange should show a reduction this month compared with January. The crisis in other commodity markets had a direct effect upon the metal markets owing to the collapse of a firm trading on the Metal Exchange. The downward movement was the more disappointing, as prices had shown a more favourable tendency during January. The average price for cash copper in February declined by 18s. 1½d., and for three months by 19s. 11d. For electrolytic copper the price was £1 0s. 7d. less than in the previous month, whilst for wire bars it was £1 0s. 10d. and for best selected £1 2s. 6d. lower. The average for tin, which showed an advance in January, was for February £3 14s. 6d. down for cash and £5 1s. 1½d. lower for three months. Prices in the lead market also, in spite of its steadiness, declined during February, and the average price for shipment in the current month was 2s. 2d. lower, whilst for shipment the third following month the price was 2s. down and the mean 2s. 1d. less than for January. The average price for spelter for shipment the current month declined by 3s. 6d., and for shipment the third following month by 4s. 1d. from the January figure, the mean being 3s. 10d. lower. The following are the official average quotations for February:—

STANDARD COPPER	Cash	£27	4	1½
	3 Months	£27	9	7⅞
	Settlement	£27	4	0
ELECTROLYTIC COPPER		£30	8	6
ELECTROLYTIC WIRE BARS		£30	12	1½
BEST SELECTED COPPER		£30	0	0
STANDARD TIN	Cash	£227	11	6
	3 Months	£223	15	7½
	Settlement	£227	11	9
LEAD	For shipment the current month	£10	4	3¾
	For shipment the third following month	£10	8	3
	Mean	£10	6	3⅜
	Settlement	£10	4	7½
SPELTER	For shipment the current month	£11	16	4½
	For shipment the third following month	£12	0	0
	Mean	£11	18	2½
	Settlement	£11	16	4½

Current Prices for Metals and Fuels.

Makers' official home trade prices, per ton, delivered buyers' stations. Sections, joists and plates are subject to a rebate to home users purchasing only from associated British Steelmakers: joists, 22s. 6d.: plates and sections, 15s. Export orders of 250 tons and over may be subject to special quotations.

PIG IRON.

	Home.	Export.
	(*D/d Teesside Area*)	
N.E. COAST—	£ s. d.	£ s. d.
Hematite Mixed Nos.	3 8 6	3 2 0
No. 1	3 9 0	3 2 6
Cleveland—	(*D/d Teesside Area*)	
No. 1	3 10 0	3 4 0
No. 3 G.M.B.	3 7 6	3 1 6
No. 4 Forge	3 6 6	3 0 6
Basic (*Less 5/– rebate*)	3 7 6	—
MIDLANDS—		
Staffs.—	(*Delivered to Black Country Station*)	
North Staffs. Foundry	3 11 0	—
„ „ Forge	3 6 6	—
Basic (*Less 5/– rebate*)	3 12 6	—
Northampton—		
Foundry No. 3	3 7 6	—
Forge	3 2 6	—
Derbyshire—		
No. 3 Foundry	3 11 0	—
Forge	3 6 0	—
SCOTLAND—		
Hematite, f.o.t. furnaces	3 11 0	—
No. 1 Foundry, ditto	3 12 6	—
No. 3 Foundry, ditto	3 10 0	—
Basic, d/d (*Less 5/– rebate*)	3 7 6	—
N.W. COAST—		
Hematite Mixed Nos.	3 12 6 d/d Glasgow 4 0 6 „ Sheffield 4 5 6 „ Birmingham	

MANUFACTURED IRON.

	Home.	Export.
LANCS.—	£ s. d.	£ s. d.
Crown Bars	9 12 6	—
Best Bars	10 2 6	—
S. YORKS.—		
Crown Bars	9 12 6	—
Best Bars	10 2 6	—
MIDLANDS—		
Crown Bars	9 15 0	—
Marked Bars (Staffs.)	12 0 0	—
Nut and Bolt Bars	7 5 0 to 7 15 0	—
SCOTLAND—		
Crown Bars	9 12 6	9 5 0
Best	10 2 6	9 15 0
N.E. COAST—		
Common Bars	9 12 6	8 15 0
Best Bars	10 2 6	9 15 0
Double Best Bars	10 12 6	10 0 0

STEEL.

	Home.	Export.
LONDON AND THE SOUTH—	£ s. d.	£ s. d.
Angles	8 10 0	7 7 6
Tees	9 10 0	8 7 6
Joists	8 17 6	7 7 6
Channels	8 15 6	7 12 6
Rounds, 3in. and up	9 10 0	8 7 6
„ under 3in.	8 14 6	7 0 0
Flats, 5in. and under	8 14 6	7 0 0
Plates, ¾in. (basis)	9 0 0	7 15 0
„ ⅞in.	9 5 0	8 0 0
„ 1in.	9 10 0	8 5 0
„ 1⅛in.	9 15 0	8 10 0
„ 1¼in.	9 10 0	8 5 0
NORTH-EAST COAST—	£ s. d.	£ s. d.
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 6
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Plates, ¾in.	8 15 0	7 15 0
„ ⅞in.	9 0 0	8 0 0
„ 1in.	9 5 0	8 5 0
„ 1⅛in.	9 10 0	8 10 0
„ 1¼in.	9 5 0	8 5 0
Boiler Plates, ¾in.	9 5 0	8 5 0
MIDLANDS, AND LEEDS AND DISTRICT—	£ s. d.	£ s. d.
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 6
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Flats, 5in. and under	8 12 0	8 17 6
Plates, ¾in. (basis)	8 17 6	7 15 0
„ ⅞in.	9 2 6	8 0 0
„ 1in.	9 7 6	8 5 0
„ 1⅛in.	9 12 6	8 10 0
„ 1¼in.	9 5 0	8 5 0
Boiler Plates, ¾in.	9 7 6	7 15 0 to 8 5 0

STEEL (*continued*).

	Home.	Export.
GLASGOW AND DISTRICT—	£ s. d.	£ s. d.
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 6
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Flats, 5in. and under	8 12 0	8 17 6
Plates, ¾in. (basis)	8 15 0	7 15 0
„ ⅞in.	9 0 0	8 0 0
„ 1in.	9 5 0	8 5 0
„ 1⅛in.	9 10 0	8 10 0
„ 1¼in.	9 5 0	8 5 0
Boiler Plates	9 5 0	8 5 0
SOUTH WALES AREA—	£ s. d.	£ s. d.
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 0
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Flats, 5in. and under	8 12 0	8 17 6
Plates, ¾in. (basis)	8 17 6	7 15 0
„ ⅞in.	9 2 6	8 0 0
„ 1in.	9 7 6	8 5 0
„ 1⅛in.	9 12 6	8 10 0
„ 1¼in.	9 10 0	8 5 0

IRELAND—	BELFAST. £ s. d.	REST OF IRELAND. £ s. d.
Angles	8 12 6	8 15 0
Tees	9 12 6	9 15 0
Joists	9 0 0	9 2 6
Channels	8 17 6	9 0 0
Rounds, 3in. and up	9 12 6	9 15 0
„ under 3in.	9 2 0	9 4 6
Plates, ¾in. (basis)	9 0 0	9 2 6
„ ⅞in.	9 5 0	9 7 6
„ 1in.	9 10 0	9 12 6
„ 1⅛in.	9 15 0	9 17 6
„ 1¼in.	9 12 6	9 15 0

OTHER STEEL MATERIALS.

	Home.	Export.
Sheets.	£ s. d.	£ s. d.
10-G. to 13-G., f.o.r.	9 0 0	8 15 0
14-G. to 20-G., d/d	10 5 0	9 0 0
21-G. to 24-G., d/d	10 10 0	9 5 0
25-G. to 27-G., d/d	11 2 6	9 17 6

The above home trade prices are for 4-ton lots and over; 2-ton to 4-ton lots, 10s. per ton extra; and under 2-ton lots, 30s. per ton extra.

Galvanised Corrugated Sheets, Basis 24-G.

Home.	£ s. d.
4-ton lots and up	13 0 0
2-ton to 4-ton lots	13 7 6
Under 2 tons	15 0 0

Export: £16 12s. 6d., c.i.f. duty paid India.
„ £11 5s. 0d., f.o.b. other markets.
„ Scandinavian Markets free.

Tin-plates.

20 by 14 basis, f.o.b. Bristol Channel Ports, 18/2 to 19/2.

Tin-plate Bars, d/d South Wales Works, £5 7s. 6d.

Billets.	£ s. d.
Basic (0·33% to 0·41% C.)	6 12 6
„ Medium (0·42% to 0·60% C.)	7 2 6
„ Hard (0·61% to 0·85% C.)	7 12 6
„ „ (0·86% to 0·99% C.)	8 2 6
„ „ (1% C. and up)	8 12 6
Soft (up to 0·25% C.), 500 tons and up	5 10 0
100 tons	5 15 0
Rails, Heavy, 500-ton lots, f.o.t.	8 10 0
„ Light, f.o.t.	7 10 0

FERRO ALLOYS.

	Per Ton.	Per Unit.
Tungsten Metal Powder	3/3 per lb.	
Ferro Tungsten	3/– per lb.	
Ferro Chrome, ¼ p.c. to 6 p.c. carbon	£23 0 0	7/–
„ „ 6 p.c. to 8 p.c.	£21 12 6	7/–
„ „ 8 p.c. to 10 p.c.	£21 12 6	7/–
„ „ Specially Refined		
„ „ Max. 2 p.c. carbon	£33 0 0	11/–
„ „ „ 1 p.c. carbon	£36 0 0	12/–
„ „ „ 0·70 p.c. carbon	£42 0 0	12/6
„ „ „ carbon free	10d. per lb.	
Metallic Chromium	2/5 per lb.	
Ferro Manganese (loose)	£10 15 0 home	
„ Silicon, 45 p.c. to 50 p.c.	£12 10 0 scale 5/– p.u.	
„ „ 75 p.c.	£17 19 6 scale 6/– p.u.	
„ Vanadium	12/8 per lb.	
„ Molybdenum	4/6 per lb.	
„ Titanium (carbon free)	9d. per lb.	
Nickel (per ton)	£200 to £205	
Cobalt	5/6d. per lb.	

NON-FERROUS METALS.

Official Prices, March 6th.

COPPER—		
Cash	£28 0 0 to £28 1 3	
Three months	£28 6 3 to £28 7 6	
Electrolytic	£31 5 0 to £31 12 6	
Best Selected Ingots, d/d Birmingham	£31 10 0	
Sheets, Hot Rolled	£56 0 0	
	Home.	Export.
Tubes, Solid Drawn (basis)	9½d.	9½d.
„ Brazed (basis)	9½d.	9½d.
BRASS—		
Ingots, 70/30, d/d Birmingham	£26 0 0 to £28 0 0	
	Home.	Export.
Tubes, Solid Drawn, 2/1 Alloy	8½d.	8½d.
„ Brazed	10½d.	10½d.
TIN—		
Cash	£215 5 0 to £215 15 0	
Three months	£212 0 0 to £212 10 0	
LEAD	£10 6 3 to £10 12 6	
SPELTER	£11 10 0 to £11 16 3	
Aluminium Ingots (British)	£100	

FUELS.

SCOTLAND.

	Export.
LANARKSHIRE—	
f.o.b. Grangemouth)—Navigation Unscreened	13/– to 13/6
„ Glasgow—Ell	16/6
„ „ Splint	17/6
AYRSHIRE—	
(f.o.b. Ports)—Steam	14/– to 14/6
FIFESHIRE—	
(f.o.b. Methil or Burntisland)—Prime Steam	14/–
Unscreened Navigation	12/6 to 13/–
LOTHIANS—	
(f.o.b. Leith)—Hartley Prime	14/– to 14/6
Secondary Steam	13/– to 13/6

ENGLAND.

YORKSHIRE, MANCHESTER—	
B.S.Y. Hard Steams	18/6 to 21/6
Furnace Coke	15/– to 17/6
NORTHUMBERLAND, NEWCASTLE—	
Blyth Best	14/3 to 14/6
„ Second	13/3
„ Best Small	10/6 to 11/–
Unscreened	12/6 to 13/6
DURHAM—	
Best Gas	14/8
Foundry Coke	18/6 to 22/6

SHEFFIELD—	Inland.
Best Hand-picked Branch	24/– to 26/–
South Yorkshire Best	21/– to 23/–
South Yorkshire Seconds	17/6 to 19/–
Rough Slacks	8/– to 9/–
Nutty Slacks	7/– to 8/6

CARDIFF— SOUTH WALES.	
Steam Coals:	
Best Admiralty Large	19/6
Seconds	19/– to 19/4½
Best Dry Large	18/9 to 19/3
Ordinaries	18/3 to 18/6
Best Bunker Smalls	13/6 to 14/–
Cargo Smalls	11/6 to 12/6
Dry Nuts	22/– to 26/–
Foundry Coke	24/– to 37/6
Furnace Coke	19/– to 21/6
Patent Fuel	21/–
SWANSEA—	
Anthracite Coals:	
Best Large	34/– to 40/–
Machine-made Cobbles	41/– to 51/–
Nuts	40/– to 50/–
Beans	25/– to 30/–
Peas	19/– to 22/6
Rubbly Culm	10/6 to 11/–
Steam Coals:	
Large	18/– to 20/6

FUEL OIL.

Inland consumption; contracts in bulk.
Exclusive of Government tax of 1d. per gallon.

Ex Ocean Installation.	Per Gallon.
Furnace Oil (0·950 gravity)	3½d.
Diesel Oil	4d.

Manchester prices ½d. per gallon extra.

French Engineering Notes.

(From our own Correspondent in Paris.)

Output Restriction.

THE clauses of the Bill introduced into the Chamber of Deputies by the Government to render compulsory the adhesion of a minority to any plan of restriction adopted by a majority of manufacturers in a particuar branch of industry have passed through the fire of parliamentary criticism, so that the Bill will necessarily become law. It, nevertheless, had a mixed reception. Objections were raised to State intervention on the ground that it tended to restrict the liberty of producers, favoured the creation of monopolies amongst groups of big manufacturers, and would raise prices at a time when it was necessary to bring them down to an international level. These objections were met by the Government's assurance that the proposed measures would be employed prudently in abnormal circumstances, and that State control would only be exercised when required by manufacturers themselves. The avowed object of the Bill is to adjust production to consumption. The possibilities of consumption will be determined by reports of State inspectors after investigation into what may be absorbed by local markets, and the Minister of Commerce will suggest restrictions, when necessary, to manufacturers and producers, who will themselves decide upon whether they can carry them into effect. Any plan of restricted output adopted by a majority of two-thirds of the manufacturers in a particular branch of industry, representing three-fourths of the total turnover, will be submitted to an Arbitration Committee, which will examine the situation and take evidence of minorities, and, if necessary, close the works of dissident manufacturers, if the Committee approve of the majority plan. In that case, no new works will be put into operation in that branch of industry. The law will remain effective until it is repealed, so that industry will always be able to take advantage of it when required. As the majority of manufacturers make their own plans, this output restriction may put a check on industrial expansion, even in times of good trade, possibly to the detriment of technical progress. The successful operation of the law will depend upon the manner in which it is handled by the Arbitration Committee.

Railway Deficit.

In view of the removal of the heavy super-tax on passenger fares, and the cuts in wages and salaries imposed by the State economy programme, it had been hoped that the railway companies would have reduced considerably the deficit on the past year's working. On account of the slump in traffic receipts through the deepening economic crisis, the deficit still amounts to about 4000 million francs, which brings up the total for the past four years to 15,000 million francs. Most of the deficit is attributed to the heavy fiscal burden imposed on the railways by the State which takes 2660 million francs a year in the form of taxes and free service for postal, military, and other transport, as well as special low fares of a social character, which, it is claimed, should rightly fall on the State. Unless something is done to remedy the situation the railway companies will have no alternative but to continue to meet the deficit by issues of debentures, which, it is said, will ultimately reduce to zero the value of a great national asset.

Road and Rail Transport.

Some of the railway companies have entered into a number of arrangements with road hauliers on a basis of collaboration under the supervision of the Road and Rail Co-ordination Committee attached to the Ministry of Public Works. The agreements are strictly local in character, and conform to the principle that traffic must be dealt with in a manner to serve the best interests of the public with due regard to economy in public finance. Where the railways are able to carry passengers and goods more cheaply and quickly over long distances, and are equipping themselves with fast rail cars for such passenger service, there must be no competition from public vehicles on the road, but owners of road cars engaged in public transport will be associated with the railways in the collection and distribution of goods and the transport of passengers in their particular departments. The railway companies will themselves eventually abandon their road services, except in some special cases. The agreements entered into during the past two years are working quite satisfactorily, and they are now to be extended throughout the country, for which purpose the Government has issued a decree instituting in each department a Technical Departmental Transport Committee that will negotiate agreements between the railway companies and road hauliers, and see that they are properly carried out. Any difficulties arising out of the negotiations will be referred to the Co-ordination Committee for solution. The Technical Committee will include representatives of all the transport interests concerned in the department. The decree lays down strictly the conditions under which owners of public service vehicles are to work in collaboration with the railways, and provides for compensation to those owners who cannot be allowed to continue their business under the new arrangement. In a word, no more than the required number of road public service vehicles will be permitted to run in any one department as part of the general transport scheme, and the railways will be free to develop fast long-distance services without fear of competition from the road.

The "Atlantique."

The insurance dispute over the burnt-out "Atlantique" is by no means settled. It has been revived by the determination of the insurance underwriters to prove that the fire was caused by defective electrical wiring, and meetings have been held on the hull lying at Cherbourg, when the evidence of electricians is said to have supported the insurance companies' claim, while an inspection of the hull revealed that some of the wiring had not been reached by the fire, and that in several places there was, it is said, clear evidence of short circuiting. Seals were affixed to the wires, and the case may therefore be heard again on the underwriters' claim that they have no liability.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C., at 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

DYNAMOS AND MOTORS.

423,114. August 15th, 1933.—HEAT-EXCHANGE APPARATUS FOR FLUIDS APPLICABLE TO COOLERS FOR ENCLOSED DYNAMO-ELECTRIC MACHINES, Ralph Poole, of 1, Ardenpark, Bredbury, Cheshire, and Associated Electrical Industries, Ltd., of Crown House, Aldwych, Westminster.

The heat-transmitting element described in this specification comprises a metal foundation plate A and a corrugated openwork or gauze sheet B of good heat conducting material, such as copper or steel. The corrugated sheet B is secured in intimate heat-conducting relationship with the foundation plate A by welding along the troughs of the corrugations, so as to form a

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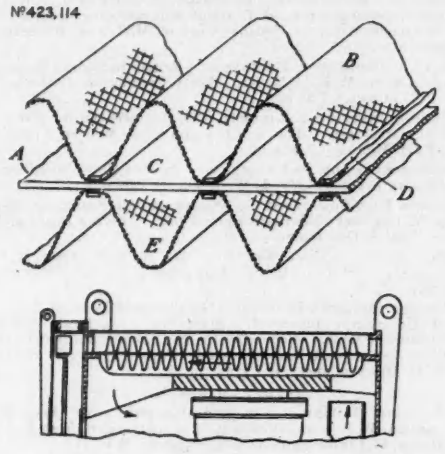

series of hollow gills C for the foundation plate A. Preferably, the gauze employed is of the type having multitudinous individual fibres or strands interwoven in relatively fine mesh. The connection of the corrugated sheet B to the foundation plate A may be improved by means of the stiffening ribs D extending along the troughs of the corrugations and secured, with the sheet B, to the foundation plate A by welding or other metal fusion union. In the form shown, the plate A is also provided on the opposing surface with similar hollow gills E. The lower illustration is a part-sectional view of a totally enclosed dynamo-electric machine provided with a cooling system in accordance with the invention.—*January 25th*, 1935

TRANSFORMERS AND CONVERTERS.

422,457. August 31st, 1934.—GRIDS IN METAL VAPOUR ARC CONVERTERS, The English Electric Company, Ltd., of Queen's House, 28, Kingsway, London, W.C.2.

Owing to the high thermal and mechanical stresses produced when the arc in metal vapour rectifiers is in operation, there is considerable risk of dislocation of the rigid grid supporting means hitherto in use with a consequent possibility of the formation of undesirable electrical contact between the anode protective tube and the grid. The object of the invention is to lessen these risks. The drawing is a longitudinal section through an external cage A mounted on one side of an anode protective tube, and shows a chain of suspension insulating means B supporting one end of each of a pair of grid-carrying rods C and D. Metal bolts E and F are secured to the upper and lower ends of the cage A, and are embraced by the counterbored cylindrical insulators G and H, which bear against the heads of the bolts. These insulators are faced by similar insulators J and K, each pair being held together by the thin sheet metal rings L and M. The insulators J and K embrace the bolts N and O respectively, of which the stem of one is screw threaded right-handedly and that of the other left-handedly, so that the chain may be tightened up by means of the screwed sleeve P. The rings L and M support the grid carrying rods C and D, which pass through apertures in the rings and in the wall Q of the anode protective tube and extend across the tube into a cage on the other side

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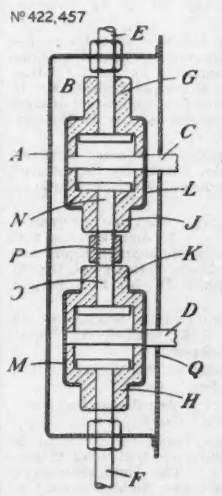

where their other ends are supported by a similar chain of suspension insulators. On a rise of temperature due to the action of the arc, the bolts E and F and N and O are free to expand longitudinally without stressing the insulators G, H, K, and J. Moreover, the rings L and M being of very thin material, form resilient means for holding the rods C and D.—*January 11th*, 1935.

422,827. May 24th, 1934.—ELECTRIC TRANSFORMERS, The British Thomson-Houston Company, Ltd., of Crown House, Aldwych, London, W.C.2.

In current transformers of the pot type the active parts are often embedded directly in an insulating material or composition. If a transformer of this kind is subjected to considerable overcurrents, such as occur in short circuits in the supply, the primary winding and to a certain extent also the secondary winding will be very highly heated. According to the invention, this and other disadvantages are avoided. The primary winding A lies in a shell B of metal or insulating material which is open at the top. The shell is provided in the end walls with passages C for the limb D of the core, the yokes of which are indicted at E. A slot F prevents the formation of a short-circuit wind-in. Directly on to the iron core the secondary winding G is fitted and between it and the primary winding a tube H of insulating material is provided, which extends laterally out of the shell through the openings C and insulates the iron core and the secondary winding from the shell and the primary winding. Between the shell and the primary winding A there is a comparatively thin heat insulating layer J of asbestos, the shell itself being connected to high-tension potential, for instance, through conductive connection with one primary terminal K. The transformer is mounted in a casing, which consists of two parts L and M and is filled up in part with oil or a solid or semi-solid insulating composition N. The casing may consist wholly or partly of insulating material. The open shell B extends so far upwardly that the insulating medium surrounding it cannot gain access

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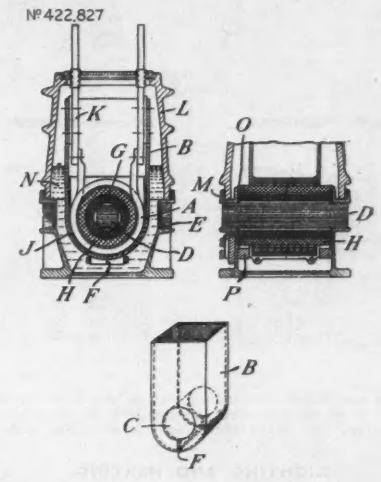

to its interior. To prevent the medium N from washing around the secondary winding and the iron core the casing L M is fitted tightly against the end surfaces of the insulating tube H, with the intermediate insertion of a yielding packing material O. The iron core embraces the outside of the casing, the material of which is kept as thin as possible at the part enclosed by the core. In the axial direction the primary winding is supported against the end walls of the shell B and the latter is held up against the casing by a ring P of insulating material. As will be clear from the foregoing, the windings and the iron core do not come into contact with the insulating material N, and this has the advantage that, on the occurrence of a short circuit, when the primary winding is suddenly very highly heated, the heat stored in the winding will not be suddenly transferred to the material N.—*January 18th*, 1935.

MEASURING AND TESTING INSTRUMENTS.

422,600. February 7th, 1934.—COMPENSATION OF TEMPERATURE ERRORS IN FERRARIS MEASURING INSTRUMENTS, Landis and Gyr A.-G., of Hofstrasse 1, Zug, Switzerland.

The subject of the invention is a device for the compensation of temperature errors in Ferraris measuring instruments. The parts of the current core are connected together by straps A so as to leave a broad air gap B. On the outside of the fastening member C there is a bimetallic strip D, which extends beneath the member C and parallel thereto along the longitudinal axis of the core. At its free end there is an iron plate E with a shading ring F. The iron plate E bridges the air gap B. If the temperature rises the bimetallic strip D moves in the direction away from the air gap B so that the latter becomes greater and consequently the current flux and the turning moment are smaller. When the temperature drops the bimetallic strip moves towards

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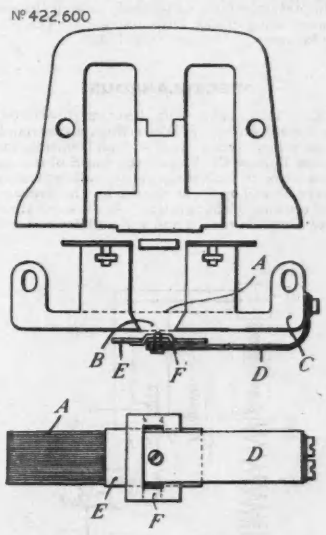

the air gap, so that the latter becomes smaller and the current flux and the turning moment thus become greater. The arrangement of the shading ring F permits any temperature error with an inductive load to be obviated. By the employment of a correspondingly thick bimetallic strip the load curve can be improved on overload. When the load increases the air gap becomes smaller by reason of the magnetic attraction between the current core and the iron plate E. For this reason the current flux increases at more than the proportional rate, whereby the current damping is partly compensated. The device has not only the property of rendering the measuring instrument independent of temperature at a unity power factor and at lower power factors, but it also possesses the property of considerably reducing the undesirable drop of the load curve on overload more especially with Ferraris meters.—*January 15th*, 1935.

422,815. January 8th, 1934.—MECHANICALLY RECORDING SOUND OSCILLATIONS, N. V. Philips' Gloeilampenfabrieken, Emmasingel, Eindhoven, North Brabant, Netherlands.

This apparatus is intended to record sound waves in such a manner that they can be reproduced visually. A sapphire stylus, or chisel, A is connected with the sound recording apparatus and bears on a film B made up of a transparent base, an

intermediate soft adhesive layer, and an opaque layer. The film, it will be seen, is creased longitudinally and the total width of the opaque film which is scraped off by the stylus will be dependent upon its penetration. It is claimed that by these

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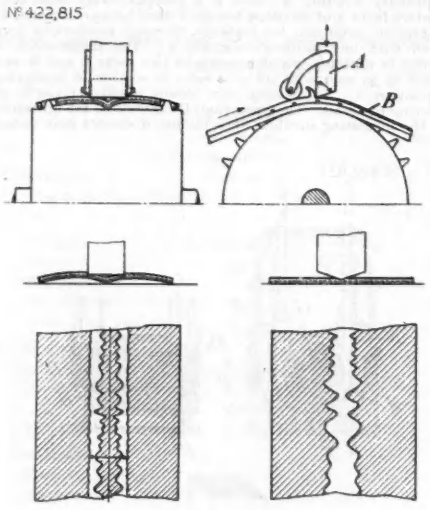

means a more robust cutting edge can be used than is possible with a V point and a flat film. Incidentally, the image is duplicated on either side of the centre line.—*January 18th*, 1935.

LIGHTING AND HEATING.

422,823. March 22nd, 1934.—Heat Exchangers, H. Livsey. Calder Vale-road, Wakefield, Yorks.

This seems to be an elementary invention, but is worthy of putting on record. The principal claim made is for:—"In sleeves employed for encircling the tubes in tubular heat

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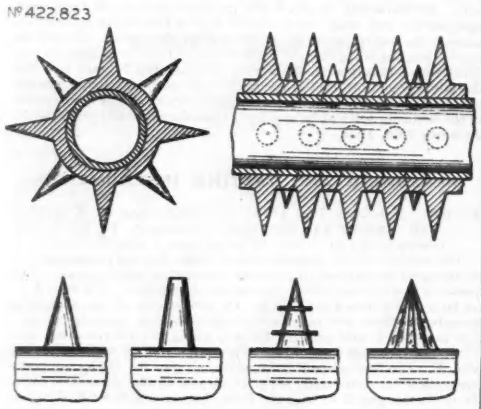

exchangers, providing or forming the exterior surface of each sleeve with a number of spikes or posts arranged in regular or staggered formation, wholly or partially around the surface, the spikes or posts being of any form and size." The illustrations are self-explanatory.—*January 18th*, 1935.

MISCELLANEOUS.

422,674. May 14th, 1934.—Oil Engine Governors, Sulzer Frères Société Anonyme, Winterthur, Switzerland.

The governor itself is indicated at A and controls the throttle B through the linkage C. Should the speed of the engine fall, through an increase of load, the governor balls will move inwards and the lever D will rock, as shown by the broken lines, to increase the opening of the throttle. At the same time the subsidiary lever E will be rocked and will pull down the slider F so

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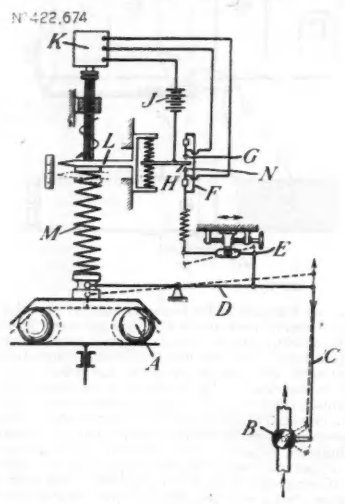

that the electrical contact G meets the piece H. A circuit will then be established from the battery J to the motor K and the abutment L of the governor spring M will be depressed. As this movement progresses the circuit between G and H is broken and the motor comes to rest, so that hunting is prevented. A rise in speed is similarly countered by contact between the piece H and the contact N, which reverses the direction of rotation of the motor K.—*January 16th*, 1935.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

TO-DAY.

Inst. of Electrical Engineers: London Students.—Savoy-place, W.C.2. "High-voltage Alternators," Mr. P. E. Crawshaw Smith. 6.30 for 7 p.m. Visit to the *Daily Herald* Printing Offices. 10 p.m.

Inst. of Electrical Engineers: N.-Eastern Students.—County Hotel, Neville-street, Newcastle-upon-Tyne. Second annual dinner. 7.30 p.m.

Inst. of Electrical Engineers: North Midland Centre.—Hotel Metropole, Leeds. Annual dinner. 7 p.m. for 7.30 p.m.

Inst. of Marine Engineers.—85/88, The Minories, E.C.3. Annual general meeting. 6 p.m.

Inst. of Metals: Sheffield Local Section.—At University, Sheffield. "Electric Annealing and Heat Treatment Furnaces," Mr. A. G. Lobley. 7.30 p.m.

Inst. of Mechanical Engineers.—Storey's-gate, S.W.1. Informal meeting. Prof. B. P. Haigh will introduce discussion on "Recent Work in Testing Steel of Mild and Moderate Tensile Strength." 7 p.m.

Inst. of Production Engineers.—British Industries House Marble Arch, W.1. "Modern Wood Production Methods," Mr. C. Williams. 7.30 p.m.

Junior Inst. of Engineers.—39, Victoria-street, S.W.1. Informal meeting, "The Construction of a Modern Liner," Mr. E. H. Brooks. 7.30 p.m.

Keighley Assoc. of Engineers.—Queen's Hotel, Keighley. "Foundry Practice," Mr. A. W. Walker. 7.30 p.m.

North-East Coast Inst. of Engineers and Shipbuilders.—At Mining Inst., Newcastle-upon-Tyne. "Flying Boats and their Possible Developments," Mr. A. Gouge. 6 p.m.

Royal Inst. of Great Britain.—21, Albemarle-street, W.1. Discourse, "Future of British Agriculture," Sir John Russell. 9 p.m.

Soc. of Chemical Industry.—In Chemical Dept. of Liverpool University, Liverpool. Symposium on Meat, "The Chemistry of Meat." Papers by Dr. E. C. Smith and Mr. L. C. Baker. 3–5 p.m. "Meat Storage." Papers by Dr. T. Moran and Mr. Hal Williams. 6–7 p.m.

SATURDAY, MARCH 9TH.

Finsbury Technical College Old Students' Assoc.—Trocadero, W.1. Annual dinner. Full particulars from F. R. C. Rouse, 15, Clifton-gardens, Golders Green, N.W.11.

MONDAY, MARCH 11TH.

Bradford Engineering Soc.—Technical College, Bradford. "The Adaptability of Pressure Piles for Underpinning and Strengthening Foundations," Mr. G. Ivan Cope. 7.30 p.m.

Inst. of Electrical Engineers: S. Midland Centre.—Visit to B.B.C. Broadcasting Station, Droitwich. 3 p.m. James Watt Memorial Inst., Birmingham. "The Droitwich Broadcasting Station" Messrs. N. Ashbridge, H. Bishop, and B. N. MacLarty. 6.15 for 7 p.m.

Inst. of Metals: Scottish Local Section.—At 39, Elmbank-crescent, Glasgow, C.2. Annual general meeting. Paper, "Welding," Dr. J. H. Peterson. 7.30 p.m.

Royal Soc. of Arts.—John-street, Adelphi, W.C.2. "Factory Accidents: Measures for Their Prevention," Lecture iii, Mr. Leonard Ward. 8 p.m.

Stephenson Locomotive Soc.—King's Cross Station, N.1. "Railway Snapshots: Ancient and Modern," Mr. A. E. L. Thorne. 6.30 p.m.

TUESDAY, MARCH 12TH.

Illuminating Engineering Soc.—Joint meeting with the Royal Aeronautical Soc., at Inst. of Mechanical Engineers, Storey's-gate, S.W.1. "Recent Developments in the Lighting of Airways and Aerodromes," Mr. H. N. Green. 6.30 for 7 p.m.

Inst. of Automobile Engineers.—King's Head Hotel Coventry. "Small Marine Engines," Mr. A. G. Pendrell. 7.30 p.m.

Inst. of British Foundrymen: Lancashire Branch.—Municipal College, Ormerod-road, Burnley. A brief description of Sand Testing Apparatus recommended by the B.C.I.R.A. and used by students of Burnley Municipal College, Mr. G. Whittaker; and "Metals as Liquids: The Application of Laws Governing Liquids Applied to Liquid Metals," Mr. H. Buckley. 7.15 p.m.

Inst. of Electrical Engineers: North Midland Students.—At the Hull Corporation Electricity Department, Ferensway, Hull. "Power Transformers," Mr. L. F. Southorn. 8 p.m.

Inst. of Electrical Engineers: Scottish Centre.—At Royal Technical College, Glasgow, C.1. Joint meeting with Students' Section. "A Cathode Ray Oscillograph Equipment Embodying a High-voltage, Gas-filled, Sealed-glass, Oscillograph Tube," Professor S. Parker Smith, Dr.-Ing. C. E. Pzegho, and Mr. E. Bradshaw. 7.30 p.m.

Inst. of Engineers and Shipbuilders in Scotland.—39, Elmbank-crescent, Glasgow, C.2. "A Diesel-electric Paddle Ferry Boat," Mr. M. E. Denny. 7.30 p.m.

Inst. of Marine Engineers.—85/88, The Minories, E.C.3. Symposium on "High-pressure Boilers." 6 p.m.

Inst. of Mechanical Engineers: South Wales Branch.—At Royal Metal Exchange, Swansea. Paper. 6 p.m.

Inst. of Metals: N. East Coast Local Section.—In the Electrical Engineering Lecture Theatre, Armstrong College, Newcastle-upon-Tyne. Discussion, "The Improvements of White Bearing Metals for Severe Service: Some General Considerations," Mr. D. J. Macnaughton. 7.30 p.m.

Inst. of Metals: Swansea Local Section.—At Y.M.C.A., Swansea. Annual general meeting. Paper, "Some Recent Developments in the Hardening of Non-ferrous Metals by Heat Treatment," Mr. W. T. Griffiths. 6.15 p.m.

Royal Aeronautical Soc.—Joint meeting with the Illuminating Engineering Soc., at Inst. of Mechanical Engineers, Storey's-gate, S.W.1. "Recent Developments in the Lighting of Airways and Aerodromes." 6.30 p.m.

WEDNESDAY, MARCH 13TH.

Inst. of Civil Engineers.—Students' afternoon visit to the blast-furnaces of the Ford Motor Company, Dagenham.

Royal Soc. of Arts.—John-street, Adelphi, W.C.2. "Properties, Characteristics, and Uses of Stainless Steel," Mr. S. A. Main. 8 p.m.

THURSDAY, MARCH 14TH.

Inst. of Automobile Engineers.—Merchant Venturers' Technical College, Bristol. "Small Racing Cars," Mr. H. N. Charles. 7.30 p.m.

Inst. of Electrical Engineers.—Savoy-place, W.C.2. "The Engineer Administrator," Mr. E. S. Byng. 5.30 for 6 p.m.

Inst. of Civil Engineers: Birmingham and District Assoc.—James Watt Memorial Inst., Birmingham. "Vibrations in Engineering Structures," Prof. C. E. Inglis, F.R.S. 5.30 for 6 p.m.

Inst. of Marine Engineers: Junior Section.—85/88, The Minories, E.C.3. "The Manufacture and Testing of Steel Forgings," Dr. W. H. Hatfield. 7 p.m.

Inst. of Mechanical Engineers: North-Western Branch.—Engineers' Club, Manchester. "Worm Gear Performance," Dr. H. E. Merritt. 7.15 p.m.

Inst. of Mechanical Engineers: Southern Branch.—Municipal College, Portsmouth. "Compression-ignition Engines," Mr. C. B. Dicksee. 7.15 p.m.

Inst. of Mechanical Engineers: Yorkshire Branch.—Hotel Metropole, Leeds. Chairman's address, "A Survey of Engineering and Metallurgical Progress," Mr. G. E. Wolstenholme. 7.30 p.m.

Inst. of Metals: London Local Section.—In Rooms of Soc. of Motor Manufacturers and Traders, Ltd., 83, Pall Mall, S.W.1. "Failures in Service," Dr. H. J. Gough, F.R.S. 7.30 p.m.

Inst. of Structural Engineers.—10, Upper Belgrave-street, S.W.1. "Welded Construction," Mr. C. Helsby. 6.30 p.m.

Manchester Association of Engineers: Students.—Manchester Limited Restaurant, Royal Exchange, Manchester. Annual social and dance.

FRIDAY, MARCH 15TH.

Chemical Engineering Group.—Joint meeting with Plastics Group at Chemical Soc., Burlington House, Piccadilly, W.1. "Plastics in a Chemical Works," Mr. M. B. Donald. 8 p.m.

Junior Inst. of Engineers.—39, Victoria-street, S.W.1. Informal meeting. "Old-time Engineers and Experiments," Mr. A. W. Marshall. 7.30 p.m.

Inst. of Structural Engineers: Midland Counties Branch.—At Nottingham. "The Lay-out, Design, and Construction of Aerodromes and Airports," Mr. H. E. Brooks-Bradley. 7 p.m.

Physical Soc.—At Imperial College of Science and Technology, S. Kensington, S.W.7. Annual general meeting. 4.45 for 5 p.m.

Railway Club.—At Royal Scottish Corpn. Hall, Fetter-lane, E.C.4. "An Introduction to Railway Heraldry," Mr. G. W. J. Potter. 7.30 p.m.

Royal Aeronautical Soc.—At Inst. of Electrical Engineers, Savoy-place, W.C.2. "New Developments in the Autogiro," Señor Juan de la Cierva. 6.30 p.m.

Royal Inst. of Great Britain.—21, Albemarle-street, W.1. Discourse, "The Art of Printing," Mr. Francis Meynell. 9 p.m.

SATURDAY, MARCH 16TH.

Inst. of Electrical Engineers: N. Midland Students.—Visit to Jowett Cars, Ltd., Idle, Bradford. Permit cards may be obtained from Mr. W. Chambers, 22, St. Ann's-mount, Leeds, 4.

Royal Inst. of Great Britain.—21, Albemarle-street, W.1. "Electromagnetic Radiations," Lord Rutherford. 3 p.m.

MONDAY, MARCH 18TH.

Engineers' German Circle.—At Inst. of Mechanical Engineers', Storey's-gate, S.W.1. "New Trends of Development in German Refrigerator Design," Prof. Dr. Ing. R. Plank. 5.15 for 6 p.m.

Inst. of Automobile Engineers.—At Inst. of Engineers and Shipbuilders in Scotland, 39, Elmbank-crescent, Glasgow, C.2. "Small Marine Engines," Mr. A. G. Pendrell. 7.45 p.m.

TUESDAY, MARCH 19TH.

British Assoc. of Refrigeration.—At Inst. of Marine Engineers, Minories, E.C.3. "Household and Commercial Refrigeration, with Special Reference to Dry Absorption Machines," Professor Dr.-Ing. R. Plank, of Karlsruhe University. 6 p.m.

Inst. of Metals: Birmingham Local Section.—At James Watt Memorial Inst., Birmingham. "Bearing Metals," Mr. R. T. Rolfe. 7 p.m.

Soc. of Glass Technology: Midland Section.—Talbot Hotel, Stourbridge. Second annual dinner. 7.15 p.m.

WEDNESDAY, MARCH 20TH.

Inst. of Automobile Engineers.—Metropole Hotel, Leeds. "Small Marine Engines," Mr. A. G. Pendrell. 7.15 p.m.

Inst. of Structural Engineers: Midland Counties Branch, Junior Members' Section.—Star and Garter Hotel, Wolverhampton. "The Detailing of Structural Steel Work," Mr. V. H. Lawton. 7 p.m.

Royal Soc. of Arts.—John-street, Adelphi, W.C.2. "Exhaust Noise and the other Noises of Motor Transport," Wing Commander T. R. Cave-Brown-Cave. 8 p.m.

THURSDAY, MARCH 21ST.

Inst. of Mechanical Engineers: Midland Branch.—James Watt Memorial Inst., Birmingham. Thomas Lowe Gray Lecture, "A Survey of Ships and Engines," Mr. Loughnan St. L. Pendred. 6.30 p.m.

Inst. of Structural Engineers: Yorkshire Branch.—Hotel Metropole, Leeds. "Stresses in the Steel Reinforcement of Concrete Structures," Mr. R. H. Evans. 7 p.m.

FRIDAY, MARCH 22ND.

Assoc. of Ex-Siemens' Men.—Gatti's Restaurant, King William-street, W.C.2. Smoking concert. 7.30 p.m.

Inst. of Electrical Engineers: London Students.—Savoy-place, W.C.2. "Power Plant for Automatic Telephone Exchanges," Mr. K. B. Baldwin. 6.30 for 7 p.m.

Inst. of Mechanical Engineers: London Graduates' Section.—Connaught Rooms, Great Queen-street, W.C.2. Dinner-dance. 7.30 for 8 p.m.

Inst. of Mechanical Engineers: Midland Branch, Graduates' Section.—James Watt Memorial Inst., Birmingham. "Steam Generation from the Sensible Heat in Waste Gases," Major W. Gregson. 7.30 p.m.

Inst. of Metals: N.E. Coast Local Section.—In Electrical Engineering Lecture Theatre, Armstrong College, Newcastle-upon-Tyne. "A Modern Copper Refinery," Mr. R. D. Burn. 7.30 p.m.

Inst. of Production Engineers.—British Industries House, Marble Arch, W.1. "The Finishing of Metals," Messrs. J. E. E. Baskerville and C. W. Benfield. 7.30 p.m.

Inst. of Sanitary Engineers.—Caxton Hall, S.W.1. "The Manufacture of Cast Iron Pipes, with Special Reference to Prevention of Corrosion," Mr. P. H. Wilson. 6 p.m.

Junior Inst. of Engineers.—39, Victoria-street, S.W.1. "Practical Fuel Oil Burning," Mr. P. C. Griffiths. 7.30 p.m.

SATURDAY, MARCH 23RD.

Inst. of Electrical Engineers: London Students.—Visit to Research Laboratories of the General Electric Company, Ltd., Wembley. 3 p.m.

Inst. of Mechanical Engineers: London Graduates' Section.—Annual visit to works of Messrs. Short Brothers and Blue Circle Cement Company, Rochester.

Erratum: "The Metallurgist."—On page 5 of the February issue of The Metallurgist, column 2, lines 8 and 9, for "one or two million" read "one or two hundred thousand."